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Integrated Backgrounding and Finishing Programs that Target Specific Consumer Markets

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Abstract:

The objectives of this study were to develop integrated backgrounding and finishing systems that target carcass quality. Cattle fed backgrounding diets based on grain screening pellets (GSP) performed similar to or better than cattle fed barley based diets. Feed savings per head ranged from $13 to $25 for the GSP fed cattle. GSP were found to have an energy content of 3.3 Mcal DE kg DM (75% TDN). Results indicated that the 1996 NRC beef model over-predicted DMI and under-predicted ADG of limit fed cattle under Saskatchewan conditions. Two trials were conducted to determine the effects of breed type, backgrounding program, and backfat endpoint on the performance and carcass characteristics of feedlot steers. It was concluded that breed type, backgrounding program, and USBFEP were effective in altering growth and could be used to target carcass traits of interest for value-based marketing programs. Work carried out by Agriculture and Agri-Food Canada indicates beef calves can be successfully backgrounded in the fall by grazing Italian ryegrass. By extending the grazing season with Italian ryegrass large amounts of very high quality forage can be made available to the calves. Respiratory health problems, feeding and labor costs, and costs associated with harvesting, storage and feed loss can all be reduced in the fall through the extension of the grazing season.

Executive Summary:

This project is a co-operative project between the University of Saskatchewan , Department of Animal and Poultry Science and Agriculture and Agri-Food Canada. It has the following objectives:

1. Develop integrated backgrounding and finishing systems that will allow cow-calf and feedlot operators to produce beef of high value for specific markets.
2. Determine the economic impact of backgrounding calves on Saskatchewan beef production, and to lower the cost of backgrounding in Saskatchewan.
3. Liaison with the beef industry to ensure viability and applicability of research results.

At the University of Saskatchewan a project has been initiated to look at integrated backgrounding and finishing programs. This program includes industry co-operators: Heartland Livestock Ltd., New-Life Feeds, Saskatoon, Prairie Malt, Biggar and PoundMaker Agri-Ventures of Lanigan, Saskatchewan. Two areas of study are involved in this work. They include an evaluation of grain screening pellets as opportunity feeds for backgrounding programs and the use of computer models that can improve the consistency and predictability of backgrounding gains in the feedlot. The second area of study is integration of backgrounding and finishing systems to target specific quality endpoints that may be unique to a given market (i.e. Canadian vs American market specifications). A summary of the work follows:

a. Two years of feeding trials were conducted that evaluated low cost backgrounding programs using byproducts of the grain cleaning industry (i.e. grain screening pellets). The conclusions of this work were: Over the two years of this study, cattle fed backgrounding diets based on grain screenings performed similar to or better than cattle fed barley based diets formulated to similar energy and protein levels. Feed cost savings per head over the 2 years of the study ranged from $13 to $25 for the grain screening fed cattle. The superior performance observed in the 2 years of this study with grain screening based-diets suggests that the energy value commonly used for grain screenings underestimates their actual energy value.

b. The results of the backgrounding trials highlighted the need to determine the true feeding value of grain screening pellets, specifically the need to collect information on dry matter intake, digestible energy content and the extent and site of digestibility of specific nutrient fractions (i.e. dry matter, crude protein, fibre, energy). To this end, two studies were carried out. These included an in situ rumen nylon bag study and two nutrient digestibility trials. To summarize this work, it was found that grain screenings have an energy content of 3.3 Mcal DE kg DM or 75% TDN. The crude protein content of this feed is 80% digested in the rumen with 75% of the remainder digested in the lower tract. As such the protein content of grain screenings is an available protein for ruminants that

supports microbial growth in the rumen and thus the protein needs of the animal. The fact that grain screenings have 89% of the energy value of barley suggests that the superior performance of cattle fed this feed in the growing trials was due to underestimation of their energy content.

c. Evaluation of the 1996 NRC computer model involved comparing actual performance (ADG, feed intake, feed conversions) of the cattle fed backgrounding diets based on opportunity feeds to that predicted by the Cornell Model. All feed was analyzed according to the CNCP system. This information was used along with cattle type, environmental and pen conditions to predict the performance of the cattle. The intent was to determine if this new method of computer prediction of cattle growth could improve on our ability to formulate rations that result in consistent and predictable performance of our calves in backgrounding programs. Results indicated that the 1996 NRC beef model over-predicted DMI and under-predicted ADG of limit fed cattle under Saskatchewan environmental conditions. Under-prediction of ADG was attributed to the overestimation of maintenance energy needs under the conditions of this study.

d. The final area of study examined the integration of backgrounding and finishing programs to target desired consumer markets. Two trials were conducted to determine the effects of breed type, backgrounding program, and backfat endpoint (USBFEP) as determined by ultrasound on the performance and carcass characteristics of feedlot steers. Trial 1 utilized 144 large-framed (LF) Charolais (304.6 ± 16.3 kg) and 144 medium-framed (MF) Hereford- cross steers (294.8 ± 20.9 kg). Trial 2 utilized 88 MF Angus (289.5 ± 15.0 kg), 88 LF Charolais (299.8 ± 17.7 kg), and 88 MF Hereford-cross (291.1 ± 20.9kg) steers. Within breed type, Short (70 d) or Long (126 d) backgrounding programs (Trial 1) and 6 or 12-mm USBFEP (Trial 1 and 2) were assigned. In both trials, carcass size was increased ($P < 0.05$) for the LF Charolais-cross steers and for the longer backgrounding and the fatter USBFEP treatments. Lean meat yield was greater ($P < 0.05$) for Charolais- than Hereford-cross steers (Trial 1) and for the leaner USBFEP (Trial 1 and 2). Marbling was greater ($P < 0.05$) for Angus- (Trial 2) and Charolais- (Trial 1 and 2) than Hereford-cross steers (Trial 1 and 2), and for the fatter endpoint (Trial 1 and 2). It was concluded that breed type, backgrounding program, and USBFEP were effective in altering growth and could be used to target carcass traits of interest for value-based marketing programs.

The fall grazing program for backgrounding beef cattle on Italian ryegrass, an annual not previously grown in Saskatchewan was initiated at the Melfort Research Station during the growing season of 1994. This is a jointly funded research effort involving Horned Cattle Trust Fund, Agricultural Development Fund and the Beef Development Fund to develop integrated backgrounding and finishing systems for cow-calf and feedlot operators. In

each of two years (1995/96 & 1996/97) animals were early weaned or fall weaned and grazed Italian ryegrass or backgrounded on silage in a feedlot. In an another trial, a local producer initiated a joint fall grazing trial, utilizing purchased calves from an auction market. In all the fall grazing trials no major health problems were observed whereas purchased animals being backgrounded in a feedlot required treatment for pneumonia. In this report, work is also presented from Agriculture Canada, LaCombe, Ab., where this phase of the project was continued. This work centers on the economic efficiencies of backgrounding and finishing systems for spring and fall born calves which incorporates the extended grazing systems developed initially at Melfort.

With regard to industry liaison, contact was made with provincial livestock specialists in co-operating with their backgrounding extension program. An economic analysis team met to spear head the initial planning of this project. Two field days were organized and 4 feature articles (3 in Canadian Cattlemen Magazine) on the research conducted for this project have been printed. The Saskatchewan Beef Symposium at the University of Saskatchewan was focused on backgrounding programs as its theme in 1995, while the 1996 and 1998 programs highlighted results from the research and farm field trials contained in this report. In addition talks were given by researchers involved in the study at producer meetings in Manitoba, Saskatchewan, Alberta and British Columbia. A fact sheet on the agronomy of Italian ryegrass was produced and distributed throughout the province. The ryegrass technology was adopted by 15 producers for late fall grazing for 1996. A factsheet on the use of grain screenings in beef cattle diets was developed in 1998 by the authors in conjunction with Saskatchewan Agriculture and Food. Finally, the research is presently being published in the scientific literature such that it will be readily available to extension and research specialists. Two papers have been published in the Canadian and American Journals of Animal Science with 2 more in progress.

The conclusions of this study include:

1. Considering nutrient analysis, and the carbohydrate and protein fraction profile, GSP would be good source of energy and protein for ruminants. The digestible energy value of grain screening pellets (3.3 Mcal DE kg DM or 75% TDN) was 11% lower than that of barley.

2. The nutrient content of GSP used in this study showed that the variation in nutrient content is reasonably consistent with starch (% of NSC) and NPN (% of CP) having the greatest variability of the nutrients analyzed.

3. Grain screening pellet-based diets resulted in consistent superior gains at lower costs than barley grain-based diets for backgrounding steers.

4. These results indicate that management can be manipulated to fit cattle to specific markets.

5. Operators involved with value-based marketing programs that target superior marbling scores could incorporate feeding cattle to a 12 mm USBFEP. Of the three breed-types used in this study, Hereford-cross cattle would be expected to perform poorly in such programs.

6. Programs that target larger, leaner carcasses should incorporate a feeding program based on LF late maturing cattle finished to a 6 mm USBFEP, following a 126 day backgrounding program.

7. Operators involved with value-based programs that target carcasses with high lean content, superior marbling and lighter carcasses need to consider the negative effects of longer backgrounding programs or feeding to fatter end-points particularly for LF cattle. These include larger carcasses, reduced lean content and in the feedlot, poorer gains and feed:gain ratios.

8. Under the conditions of this study the 1996 NRC beef model under-predicted average daily gain and over-predicted dry matter intake of cattle limit fed backgrounding diets under western Canadian feeding conditions.

9. The NRC Beef Model requires modification to become more user friendly to be a useful tool in the feeding industry in Western Canada.

10. Beef calves can be successfully backgrounded in the fall by grazing on Italian ryegrass. By extending the grazing season with Italian ryegrass large amounts of very high quality forage can be made available to the calves.

11. Respiratory health problems can be reduced in the fall through extension of the grazing season as compared to housing newly weaned or transported calves in a confined feedlot. Feeding costs and harvesting storage and feed loss costs and labor costs can be reduced in the fall through the extension of the grazing season.

12. Large numbers of calves can graze on small acreages of Italian ryegrass due to its very high quality and productivity. Strip grazing of Italian ryegrass is essential in reducing residue problems at seeding time the following year. Extra tillage will be required to work in the residue.

13. Depending on snow and late fall winter conditions, producers will need to decide how long they wish to extend the grazing season. It would be advisable to provide some form of portable shelter and bedding if calves remain out in the early winter snows.

14. It is highly recommended that the Italian type of ryegrass such as "Maris Ledger" be seeded rather than the Westerwold type "Aubade" as the Westerwold type will produce seed in the year of seeding. Seed shatter will occur and volunteer growth will occur the next year.

15. If the Italian type is unavailable then the Westerwold type should be planted in fields designated for grazing. The crop should be heavily grazed in mid-summer and re-grazed in the late fall after sufficient regrowth has occurred. The initial growth of annual ryegrass is slow in the spring however, with lots of moisture large yields will be available for late fall grazing.

Technical Report

Chapter 1.

1. Introduction:

Backgrounding could have increased the economic returns to the Saskatchewan beef industry by $64.5 million in 1992. This figure is based on the fact that 300,000 calves were exported that weighed less than 700 lbs. Producers have been reluctant to background cattle due to financial and market uncertainty. These concerns can be overcome by determination of the long term economic impact of farm-based cattle feeding programs and by using marketing techniques such as break-even analysis, co-operative feeding agreements, close working relationships with your livestock sales person and in some cases, through the use of forward contracting.

Management and marketing of cattle today requires a knowledge of delivery dates, target weights and carcass quality requirements (i.e. weight, frame and flesh score and carcass grade and marbling score). Failure to produce cattle with the right quality specifications can result in discounted prices and reduced profits. Market forces demand a thorough understanding of how production systems simultaneously influence rates of growth, carcass composition and quality, and cost of production. Such integrated information is presently lacking for Saskatchewan.

2. The objectives of this project are to :

1. Develop integrated backgrounding and finishing systems that will allow cow-calf and feedlot operators to produce beef of high value for specific markets.
2. Determine the economic impact of backgrounding calves on Saskatchewan beef production, and to lower the cost of backgrounding in Saskatchewan.
3. Liaison with the beef industry to ensure viability and applicability of research results.

3. Research Results:

Since this is a co-operative project between the Department of Animal and Poultry Science and Agriculture and Agri-Food Canada at Melfort this report will detail separately work carried out at both locations.

A. Trials conducted at the Department of Animal and Poultry Science, University of Saskatchewan:

Due to the timing of the funding of this project, it was not possible to begin work until the spring/summer of 1995. Since then the projects have been initiated that focus on four areas. These include:

1. The feeding value of grain screening pellets for ruminants: Chemical composition and nutrient utilization.

2. Backgrounding cattle with by-products of the grain screening industry.
3. Manipulation of cattle growth to target carcass quality.
4. Evaluation of the 1996 National Research Council 1996 Beef Nutrition Model.

This work is detailed in Chapters 2 through 5 of this report.

B. Trials conducted at Agriculture and Agri-Food Canada, (Lacombe, Ab. and Melfort, Sk.):

1. Extending the grazing season for growing cattle using annual ryegrass.
2. Producer demonstration trial with annual ryegrass.
3. Comparison of the economic efficiencies of backgrounding and finishing systems for spring and fall born calves which incorporates the extended grazing systems developed initially at Melfort.

This work is detailed in chapter 6 of the following report.

Chapter 2. The Feeding Value of Grain Screenings for Ruminants: Chemical Composition and Nutrient Utilization

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Abstract

The objectives of this study were to determine the chemical and nutrient utilization characteristics of GSP for ruminants. One ruminally fistulated cow was used to determine ruminal nutrient degradability characteristics of GSP relative to barley grain. Twenty-one growing lambs were used to determine voluntary intake and total tract nutrient digestibility coefficients for GSP relative to regular and thin barley. Seven diets were formulated with different levels of GSP, and thin or regular barley at ratios of 100:0; 75:25; 50:50; 25:75. On dry matter basis GSP contained 337 $\pm$ 17.4 g kg^{-1} NDF, 209 $\pm$ 21.1 g kg^{-1} ADF, 151 $\pm$ 11.1 g kg^{-1} CP, and 262 $\pm$ 61.5 g kg^{-1} starch. Ruminal degradability of DM and NDF of GSP was lower ($P < 0.05$) while that for CP was higher ($P < 0.05$) than barley grain. Ruminal degradability of starch for GSP and barley exceeded 900 g kg^{-1}. Results of the sheep trial showed that as the level of GSP increased, voluntary intake increased ($P < 0.05$) and total tract digestibility coefficients of DM, NDF, and GE decreased ($P < 0.05$). The digestibility coefficient of DM, NDF, and GE for GSP were 666 g kg^{-1}, 294 g kg^{-1}, and 698 J kJ^{-1}, respectively. The DE content of GSP (13.8 MJ kg^{-1}) was similar to that of thin barley and 11% lower ($P < 0.5$) than that of regular barley. It was concluded that while GSP exhibited reduced ruminal and total tract nutrient utilization relative to regular barley, this feed product is a good source of energy and protein for growing ruminants.

Introduction

Grain screenings are a byproduct obtained in the process of cleaning grain for export or use in specialized markets within Canada. Screenings are defined by the Canadian Grain Commission (1996) and are divided into four classes based on their allowable content of parental material, broken or shrunken kernels, hulls, weed seeds, and dust. These include number 1 and 2 feed screenings, uncleaned screenings, and refuse screenings. Number 1 and 2 feed screenings contain at least 35% by weight of the parental grain (i.e. whole, broken or shrunken kernels). Uncleaned screenings would meet this requirement if cleaned. Refuse grain screenings are defined as screenings that do not meet the requirement for parental material for Number No. 1 or No. 2 feed screenings and contain a higher proportion of dust, chaff, and weed seeds (Beames et al. 1986; Stapleton et al. 1980). Refuse grain screenings can be fed as received or pelleted. Grinding and pelleting is often carried out to enhance digestibility and decrease viability of weed seeds (Janzen 1995). Processing often takes the form of grinding and pelleting.

Tait et al. (1986) conducted work on the utilization of grain screenings for pigs and sheep. They concluded that No. 1 feed screenings were suitable as a feed for pigs, and that refuse screenings which were

more variable in nutrient content were suitable for ruminant diets. The variability in nutrient content of GSP relative to other sources of nutrients has not been determined.

In addition to refuse screening pellets, the cleaning of grain for export or other uses such as malting barley can result in a number of different cereal grain byproducts. An example is thin barley, a byproduct of cleaning high quality barley for malting. Thin barley consists entirely of barley kernels that pass through a 1.98-mm screen, plus weed seeds. However, the fines and dust portions that are obtained in the cleaning process are not added to the thin barley product. No information exists on the feeding value of this byproduct from the cleaning of barley from the malt industry.

This study was conducted to measure the variation in chemical composition of GSP and to measure voluntary intake, nutrient digestibility and DE content of GSP relative to regular and thin barley. A second objective was to determine the ruminal degradability characteristics of GSP relative to barley grain.

Materials and Methods

Sample Collection and Chemical Characterization

Processed GSP were obtained from New-Life Feeds of Saskatoon, SK over the time frame 1995 to 1997. In total, 18 loads were obtained. The GSP consisted of refuse grain screenings (850 g kg^{-1}) and lentil screenings (150 g kg^{-1}) which were blended, ground and steam pelleted (2 mm × 10 mm). Each load was subsampled and ground to pass a 1-mm screen using a Christie-Norris mill. For comparison purposes, 18 samples of commercially available barley were collected from the University of Saskatchewan feed mill. The samples were analyzed for DM, CP (Kjeldahl nitrogen x 6.25), ether extract, ash, ADF and acid detergent lignin following the procedures of the Association of Official Analytical Chemists (AOAC 1990). Neutral detergent fiber was determined according to the procedure of Van Soest et al. (1991). Total starch was measured as described by McCleary et al. (1997).

Total carbohydrates were fractionated based on rates of ruminal degradation into rapidly, intermediately and slowly degradable fractions using the equations of Sniffen et al. (1992). Soluble protein, non-protein nitrogen, as well as neutral and acid detergent insoluble protein were determined according to Licitra et al. (1996). Total true protein was estimated according to Sniffen et al. (1992) and was further sub-fractionated into rapidly, intermediately and slowly degradable fractions based on rates of degradation in the rumen.

In Situ Ruminal Disappearance

In situ ruminal nutrient disappearance of GSP was determined using one non-lactating Holstein cow (850 kg body weight) fitted with a flexible rumen cannula. The cow was fed a diet consisting of 50% barley silage and 50% GSP at 1.5% of body weight (DM basis). Treatments included GSP collected in two different years (1995 / 96 and 1996 / 97). For comparison purposes a commercial barley sample was also

included. All samples were ground through a 2-mm screen using a Brinkmann Retsch mill (ZM1, Rexdale, ON).

Samples (7 g) of each feed were weighed into nylon bags (10 × 20 cm; 50 μm pore size). The GSP samples were incubated in the rumen in duplicate for 0, 4, 8, 12, 18, and 24 h and in triplicate for 48 and 72 h. Barley samples were incubated in duplicate for 0, 2, 4, 6, 8, 12 and 18 h and in triplicate for 24 and 36 h. All incubations commenced prior to the morning feeding, with bags inserted at appropriate times and removed at the same time on the fourth morning. Three incubations were carried out for replication.

Following removal from the rumen, the bags were washed as described by McKinnon et al. (1991). The washed nylon bags were then dried in a forced air oven at 65 °C for 48 h and allowed to air equilibrate for 3 d. Contents of replicated bags at each incubation time were composited and ground using a small coffee grinder. Dry matter content was determined in the whole residues, which were then analyzed for CP (AOAC 1990), NDF (Van Soest et al. 1991), and total starch (McCleary et al. 1997).

Nutrient disappearance at each time was calculated from the concentrations of nutrients in the original samples and the residues following incubation. The disappearance values at each time point were used to estimate rumen kinetic parameters according to the equation of Ørskov and McDonald (1979) with the addition of a discrete lag time (Khorasani et al. 1994), using an iterative nonlinear regression procedure of the SAS Institute Inc. (1989). Effective ruminal degradability was estimated using the equation of Ørskov and McDonald (1979) assuming a rumen outflow rate of 5% h^{-1}.

Total Tract Digestibility and Voluntary Intake

Dietary treatments

Seven diets were formulated using graded levels of regular and thin barley in combination with GSP. The diets were composed of the following ratios (% as fed) of GSP and regular or thin barley: 100:0; 75:25; 50:50; 25:75. Regular barley (61.6 kg hL^{-1}) was obtained from the University of Saskatchewan feed mill and represented commercially available barley. Thin barley (42 kg hL^{-1}) was obtained from Prairie Malt of Biggar, SK. Both regular and thin barley were dry rolled using a commercial roller mill (Model J, Roskamp Huller Mfg. Co. Inc., Cedar Falls, IO).

Experimental animals and management

Twenty-one growing Suffolk lambs weighing an average of 44.1 ± 2.4 kg were used. The animals were randomly allocated to one of the seven dietary treatments (3 animals per treatment). The trial consisted of two 24-d periods. The experimental protocol consisted of a 9-d adaptation period where the animals were kept in floor pens (3 animals per pen) and gradually introduced to the experimental diets. Following the adaptation period the animals were weighed and transferred to individual metabolism crates with voluntary feed intake determined over a 7-d period. During this period the animals were fed to leave about 10 to 15% orts. Following the voluntary intake period, the animals were again weighed and then placed on a 3-d

restricted feeding (85% of ad libitum intake) period and fitted with fecal collection bags. This period was followed by five days of total fecal collection.

After completion of the first period, the animals were weighed and reallocated randomly to the seven dietary treatments. The same protocol was used for period two, as used in period one. During the trial, each animal was fed daily 12.5 g of a trace mineral salt mixture containing 160 g calcium, 160 g phosphorous, 1.66 g zinc, 25 mg iodine, 400 mg iron, 800 mg manganese, 14 mg cobalt, 400 IU vitamin A, 33,300 IU vitamin D and 400 IU vitamin E kg^{-1}. All animals were cared for according to the guidelines of the Canadian Council on Animal Care (1993).

Sample collection and analysis

Feces were collected once daily during the 5-d collection period immediately before the 0800 feeding, sub-sampled (10% aliquot) and frozen. All samples were thawed and dried at one time in a forced air oven at 65 °C for 72 h. The fecal samples from each animal were composited and ground through a 1-mm screen using a Christie-Norris mill. Feed samples were collected during the same period, frozen and subsequently dried and ground as per the fecal samples. Feed and fecal samples were analyzed for DM, CP (Kjeldahl nitrogen x 6.25), NDF, and ADF as described previously. Gross energy was determined using an adiabatic oxygen bomb calorimeter. Apparent nutrient digestion coefficients were calculated as the difference between nutrient intake and excretion in fecal material.

Statistical Analysis

Data from the in situ nylon bag trial were analyzed as a completely randomized design where feeds (n = 3) served as treatments and incubations (n = 3) as replicates using the General Linear Procedure of SAS (1989). Means were separated using the Student-Newman-Keuls test (Steel et al. 1997). Data from the digestibility trial were analyzed as a randomized complete block design (7 treatments) using the GLM procedure of SAS (1989) with data blocked by period. The data were examined for linear or quadratic effects of barley or thin barley inclusion rate and regression equations were developed to estimate nutrient digestion coefficients for regular and thin barley (Steel et al. 1997).

Results and Discussion

Chemical Composition of Grain Screening Pellets

Relative to barley, GSP contained more ash and ether extract ($P < 0.05$). The ash and ether extract levels reported in this study for GSP were higher than those reported for No. 1 feed screenings (Beams et al. 1986).

Carbohydrate was the major component constituting 681 and 821 g kg^{-1} of GSP and barley, respectively (Table 1). The ADF and NDF values of GSP were higher ($P < 0.05$) than those of barley (Table 1). The NDF of GSP also contained more ($P < 0.05$) acid detergent lignin than the NDF of barley.

The GSP contained 262 g kg^{-1} starch which was 54% less ($P < 0.05$) than the starch content of barley grain. Our ADF and NDF values for GSP are in good agreement with those reported by Janzen (1995).

Fractionation of total carbohydrate based on rates of degradation in the rumen showed that intermediately degradable (B2) carbohydrate was the main carbohydrate fraction in both feeds and was lower ($P < 0.05$) in GSP than in barley (Table 1). Differences in the B2 carbohydrate fraction reflects the higher starch content of barley relative to GSP.

Crude protein content of GSP in this study was greater ($P < 0.05$) than that of barley (Table 2). The CP value reported in this study for GSP is similar to that reported by Beames et al. (1986) for No. 1 feed screenings (148 g kg^{-1}) and refuse screenings (131 g kg^{-1}). It was also similar to the CP value reported for wheat screenings (155 g kg^{-1}) by Stapleton et al. (1980). Crude protein composition of GSP was different from that of barley. Grain screening pellets contained more ($P < 0.05$) soluble protein and non-protein nitrogen than barley (Table 2). The amount of protein associated with NDF and ADF was also higher ($P < 0.05$) in GSP than in barley. Differences in neutral and acid detergent insoluble protein levels between barley and GSP were consistent with differences observed for NDF and ADF content (Table 1). True protein constituted the largest part of CP in both feeds and was lower ($P < 0.05$) in GSP than in barley (Table 2). Intermediately degradable protein was the main true protein fraction in GSP (490 g kg^{-1} of CP). Considering the carbohydrate and protein profile, GSP would be expected to be highly degraded in the rumen.

It is also of interest to look at the variation inherent in the GSP and barley samples. Coefficients of variation for ether extract and starch content calculated from Table 1, show greater variation for GSP (29.2 and 25.4%, respectively) than barley (19.6 and 6.1%, respectively). In contrast, ADF values were more variable in barley than GSP (10 vs 44.2%) mainly due to the relatively low ADF values for barley. The coefficient of variation for CP content was 7.4% for GSP and 18.7% for barley. These results indicate that one can expect greater variation in the energy content of GSP compare with barley. Crude protein values should however, be more predictable in GSP.

In Situ Nylon Bag Trial

No statistical differences in ruminal kinetic parameters or effective ruminal degradability were found between the two GSP samples and thus only average values are shown (Table 3 and 4). Grain screening pellets and regular barley had similar in situ soluble and slowly degradable fractions (Table 3). However, rate of degradation of the slowly degradable DM fraction was higher ($P < 0.05$) in barley than in GSP. The soluble and slowly degradable DM fractions reported in this study for barley are within the values reported by Ramsey (1994) while the rate of degradation of the slowly degradable DM fraction for barley (30.3% h^{-1}) is within the range of 20 to 35% h^{-1} reported by Okine et al. (1994) and Lehman et al. (1995). Effective ruminal degradability of DM for GSP

was lower ($P < 0.05$) than that for barley grain. This is likely a reflection of the higher degradation rate of the slowly degradable DM fraction for barley relative to GSP. The effective ruminal degradability of DM

for barley in this study is comparable with the values reported by Arieli et al. (1995) and De Boer et al. (1987).

Grain screening pellets had a high in situ soluble CP fraction (613 g kg^{-1} of CP, Table 3). The in situ soluble CP fraction of GSP was 45% greater ($P < 0.05$) than that of barley. This is consistent with the chemical analysis, which showed higher buffer soluble protein content for GSP than for barley (Table 2). The slowly degradable CP fraction was higher ($P < 0.05$) in barley than in GSP. The slowly degradable CP fraction of GSP had a rate of degradation, which was lower ($P < 0.05$) than that of barley. Effective ruminal degradability of CP in both feeds exceeded 800 g kg^{-1}. A lower degradation rate of the slowly degradable fraction and a higher level of acid detergent insoluble protein are likely the reasons of the lower ruminal degradability of GSP protein relative to barley. The ruminal degradability of CP reported in this study for barley is comparable with that reported by De Boer et al. (1987) and Mustafa et al. (1998).

Grain screenings had a lower ($P < 0.05$) in situ soluble NDF fraction than barley (Table 4). However, the slowly degradable NDF fraction was similar in both feeds. Effective degradability of NDF of GSP was lower ($P < 0.05$) than that for barley. The lower ruminal degradability of NDF for GSP relative to barley can be attributed to the fact that NDF from GSP contained more acid detergent lignin than that from barley Table 4). Traxler et al. (1998) found that the indigestible NDF fraction increased nonlinearly as the concentration of acid detergent lignin increased. According to Sniffen et al. (1992), lignin is indigestible and acts to reduce the proportion of potentially digestible NDF.

Grain screening pellets and barley had similar in situ soluble (average 755 g kg^{-1} of starch) and slowly degradable (average 243 g kg^{-1} of starch) starch fractions. In both feeds, starch was characterized by having a high soluble and a low slowly degradable fraction. Despite the fact that ruminal starch degradability was statically higher ($P < 0.05$) for barley than for GSP, both feeds had a ruminal starch degradability that exceeded 900 g kg^{-1}. The high ruminal starch degradability of barley has been reported by several researches (Boss and Bowman 1996a; Mustafa et al. 1998).

Total Tract Digestibility Trial

All diets met CP requirements for lambs of this age and weight (NRC 1985). Crude protein and fiber levels decreased as the inclusion rate of regular or thin barley in the diets increased (Table 5). This is a result of the higher CP, NDF and ADF levels in GSP relative to barley (Table 1 and 2). The reduction in fiber levels was greater for the regular barley- than for the thin barley-based diets. Mathison et al. (1991) observed that light barley (43 kg hL^{-1}) contained more fiber than heavy barley (59 to 64 kg hL^{-1}). The thin barley (a byproduct of the malting industry) used in this trial is comparable with light barley (42 kg hL^{-1}).

Dry matter intake (g kg^{-1} and g $kg^{-0.75}$) of the lambs decreased linearly ($P < 0.05$) as the inclusion rate of regular and thin barley in the diets increased (Table 6). This can be attributed to the lower fiber and higher starch content of the barley grain-based diets relative to the diet consisting of 100% GSP. In

accordance with our results, Hatfield et al. (1997) found that DM intake by sheep decreased as the level of barley in the diet increased.

Apparent total tract digestibility of DM, NDF, and gross energy increased linearly ($P < 0.05$) as the inclusion level of both regular and thin barley increased (Table 6). However, inclusion rate of regular or thin barley had no effect on total tract digestibility of CP and ADF. Digestible energy content increased linearly ($P < 0.05$) as the level of regular barley increased (Table 6), but there was no linear or quadratic effect on digestible energy content as the thin barley inclusion rate increased.

The lower total tract digestibility of NDF and GE for the GSP- relative to the barley-based diets is consistent with the results from the in situ trial which showed lower ruminal degradability of NDF for GSP compared with barley (Table 4). Higher starch and lower fiber contents for barley relative to GSP can at least in part, explain the higher total tract digestibility of GE for barley- than for GSP-based diets.

At the 75% inclusion rate, total tract digestibility of DM, NDF, and gross energy was higher ($P < 0.05$) for the regular barley-based diets than for the thin barley-based diets. This can be attributed to the higher levels of NDF (180%) and ADF (270%) for the thin barley-based diet at the 75% inclusion rate relative to the corresponding regular barley-based diet.

Few studies on total tract nutrient digestibility of GSP have been published for ruminants. Tait et al. (1986) reported total tract digestibility of CP and ADF for No. 1 feed screenings, which are in good agreement with our values for GSP. However, our DM digestibility for GSP is somewhat lower than that reported by Tait et al. (1996) for No. 1 feed screenings.

Linear regression equations were used to predict nutrient digestibility coefficients of regular and thin barley (Table 7). The estimated total tract digestibility of DM, NDF, and GE for regular barley was 779 g kg^{-1}, 421 g kg^{-1}, and 779 J kJ^{-1}, respectively. The corresponding values for thin barley were 713 g kg^{-1}, 377 g kg^{-1}, and 746 J kJ^{-1}, respectively. The estimated DE content of the regular barley was 15.5 MJ kg^{-1}. However, no significant linear regression equations were developed for DE content of thin barley, suggesting that DE content of thin barley was not different from that of the GSP. Reported DE values for barley range from 14.5 to 15.5 MJ kg^{-1} DM (Mathison et al. 1991; Ramsey 1994; Boss and Bowman 1996b) and are comparable with the estimated digestible energy value (15.5 MJ kg^{-1} DM) reported in this study.

Conclusions

The results of this study show that GSP are a good source of degradable protein and carbohydrate for ruminants. The close agreement between disappearance values from the in situ ruminal trial and those from the total tract digestibility trial indicates that the rumen is the primary site of digestion for GSP. Due to its lower fermentable carbohydrate content, total tract utilization of DM and GE from GSP was lower than from regular barley. Consequently, the digestible energy value of grain screening pellets was 11% lower than that of barley.

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Table 1. Ash, ether extract and carbohydrate composition of grain screening pellets relative to barley (DM basis, n = 18).

	Grain screening pellets	Barley	SEM[z]
Ash (g kg^{-1})	70 ± 8.4a	22 ± 3.8b	1.48
Ether Extract (g kg^{-1})	99 ± 28.9a	24 ± 4.7b	4.88
Carbohydrate Analysis			
Acid detergent fiber (g kg^{-1})	209 ± 21.1a	57 ± 25.2b	5.48
Neutral detergent fiber (g kg^{-1})	337 ± 17.4a	227 ± 43.7b	7.84
Total carbohydrate (g kg^{-1} of DM)	681 ± 40b	821 ± 26a	7.88
Total Starch (g kg^{-1} of DM)	262 ± 61.5b	573 ± 35.0a	11.79
Non-structural carbohydrate (NSC, g kg^{-1} of DM)	368 ± 36.9b	608 ± 43.8a	9.55
Acid detergent lignin (g kg^{-1} of NDF)	148 ± 32.6a	39 ± 15.9b	6.22
Carbohydrate fractions			
Rapidly degradable (g kg^{-1} of DM)	112 ± 39b	287 ± 14a	5.88
Intermediately degradable (g kg^{-1} of DM)	256 ± 53b	578 ± 44a	11.36
Slowly degradable (g kg^{-1} of DM)	193 ± 33	194 ± 40	8.84
Unavailable (g kg^{-1} of DM)	120 ± 27b	212 ± 8.5a	4.73

[z] SEM = Pooled standard error of the mean.

a,b Means in the same row followed by different letters are different ($P < 0.05$).

Table 2. Crude protein fractions of grain screening pellets relative to barley (DM basis, n =18).

	Grain screening pellets	Barley	SEM[z]
Protein analysis			
Crude protein (CP, g kg^{-1} of DM)	151 ± 11.1a	131 ± 24.5b	4.48
Soluble protein (g kg^{-1} of CP)	344 ± 34.7a	281 ± 34.3b	8.14
Non-protein nitrogen (g kg^{-1} of CP)	218 ± 64a	112 ± 54b	13.53
Neutral detergent insoluble protein (g kg^{-1} of CP)	164 ± 31.7a	120 ± 55b	10.62
Acid detergent insoluble protein (g kg^{-1} of CP)	78 ± 15.1a	26 ± 156b	3.61
True protein fractions			
Rapidly degradable (g kg^{-1} of CP)	126 ± 73	167 ± 49	16.12
Intermediately degradable (g kg^{-1} of CP)	492 ± 38b	619 ± 82a	19.28
Slowly degradable (g kg^{-1} of CP)	86 ± 31	92 ± 57	10.41

[z]SEM = Pooled standard error of the mean.
a,b Means in the same row followed by different letters are different ($P < 0.05$)

Table 3. Ruminal kinetic parameters and effective degradability of dry matter, and crude protein of barley grain and grain screening pellets (n = 3).

	Type of feed		
	Barley	Grain screening pellets	SEM[z]
Dry Matter (DM)			
Soluble (g kg^{-1} of DM)	593	552	26.1
Slowly degradable (g kg^{-1} of DM)	292	256	24.4
Degradation rate (% h^{-1})	30.3a	5.0b	0.7
Lag time (h)	0.9	2.5	1.7
Effective Degradability (g kg^{-1})[y]	843a	679b	16.9
Crude protein (CP)			
Soluble (g kg^{-1} of CP)	424b	613a	39.6
Slowly degradable (g kg^{-1} of CP)	548a	322b	41.1
Degradation rate (% h^{-1})	19.2a	7.8b	0.4
Lag time (h)	1.2	0.7	0.3
Effective Degradability (g kg^{-1})[y]	860a	809b	7.0

a,b Means within rows followed by different letters are different ($P < 0.05$).

[z] SEM = Pooled standard error of the mean.

[y] Calculated assuming rumen flow rate of 5% h^{-1}.

Table 4. Ruminal kinetic parameters and effective degradability for neutral detergent fiber, and starch of barley grain and grain screening pellets (n = 3).

	Type of feed		
	Barley	Grain screening pellets	SEM[z]
Neutral detergent fiber (NDF)			
Soluble (g kg^{-1} of NDF)	183a	475b	19.6
Slowly degradable (g kg^{-1} of NDF)	436	497	22.7
Degradation rate (% h^{-1})	7. 6a	2.8b	0.4
Lag time (h)	5.0	6.0	0.8
Effective Degradability (g kg^{-1})	442a	217b	15.3
Starch			
Soluble (g kg^{-1} of Starch)	732	766	31.8
Slowly degradable (g kg^{-1} of Starch)	266	231	33.8
Degradation rate(% h^{-1})	48.4a	13.8b	4.8
Lag time (h)	0.3	0.7	0.4
Effective Degradability (g kg^{-1})	973a	932b	9.7

a,b Means within rows followed by different letters are different ($P < 0.05$).
[z] SEM = Pooled standard error of the mean.

Table 5. Chemical composition of diets used in the lamb digestibility trial (DM basis)

	Inclusion rate (g kg^{-1} in diet)						
		Barley			Thin Barley		
	0	250	500	750	250	500	750
Grain screening pellets (g kg^{-1} in diet)	1000	750	500	250	750	500	250
Parameter							
Crude Protein (g kg^{-1})	158	151	145	138	149	141	132
Neutral detergent fiber (g kg^{-1})	331	307	283	260	326	321	316
Acid detergent fiber (g kg^{-1})	215	182	159	115	196	188	158
Gross energy (MJ kg^{-1})	198	198	197	197	197	195	195

Table 6. Effect of regular and thin barley inclusion rate on dry matter intake and apparent total tract nutrient utilization of processed grain screening pellets.

	Inclusion rate (% in diet)									
	Barley				Thin barley				Linear contrast (P value)[x]	
Grain screening pellets (g kg^{-1} in diet)	0 1000	250 750	500 500	750 250	250 750	500 500	750 250	SEM[y]	Barley	Thin barley
Dry matter intake (g d^{-1})	2250	2270	1970	1930	2300	2030	1750	109.0	< 0.05	< 0.05
Dry matter intake (g $kg^{-0.75}$)	117	111	102	95	117	103	88	4.9	< 0.05	< 0.05
Apparent nutrient digestibility coefficient										
Dry matter (g kg^{-1})	666	701	723	753	671	693	705	8.0	< 0.05	< 0.05
Crude protein (g kg^{-1})	741	734	729	717	729	733	727	8.0	NS	NS
Neutral detergent fiber (g kg^{-1})	294	349	346	394	326	338	361	21.0	< 0.05	< 0.05
Acid detergent fiber (g kg^{-1})	256	279	237	221	265	249	230	24.0	NS	NS
Gross energy (J kJ^{-1})	698	723	738	763	695	717	728	9.0	< 0.05	< 0.05
Digestible energy (MJ kg^{-1})	13.8	14.3	14.6	15.0	13.7	14.0	14.1	0.2	< 0.05	NS

[x]Significant polynomial contrast ($P < 0.05$) indicates linear effect of GSP inclusion rate (NS = not significantly different). No quadratic effects detected.

[y]SEM = Pooled standard error of the mean.

Table 7. Linear regression equations used to estimate apparent nutrient digestibility and digestible energy content of regular and thin barley[z].

	Apparent digestibility coefficient ($g\ kg^{-1}$)			Digestible energy ($MJ\ kg^{-1}$)
	Dry matter	Neutral detergent fiber	Gross energy	
Barley				
Intercept (a)	667.8	300.6	698.9	3.31
Slope (b)	1.1	1.2	0.8	0.004
r^2	0.78	0.33	0.62	0.43
RSD	0.97	5.07	1.97	0.13
P>|T|	< 0.05	< 0.05	< 0.05	< 0.05
Estimated parameter	779	421	779	15.5
Thin Barley				
Intercept (a)	662.6	297.3	69.30	NS
Slope (b)	0.5	0.8	0.5	NS
r^2	0.41	0.20	0.25	NS
RSD	1.97	4.96	2.25	NS
P > |T|	< 0.05	< 0.05	< 0.05	NS
Estimated parameter	713	377	746	NS

[z] $Y = a + bX$

NS = Not significant ($P > 0.05$)

RSD = Residual standard deviation.

Chapter 3. Department of Animal and Poultry Science, University of Saskatchewan

BACKGROUNDING CATTLE WITH PROCESSED GRAIN SCREENINGS A BYPRODUCT OF THE GRAIN INDUSTRY.

Abstract

The objective of this trial was to examine the performance of backgrounded feeder cattle fed diets based on grain screening pellets (GSP). Two trials were conducted over the years 1995/96 and 1996/97. Trial 1 was a 2x2 factorial with 150 medium frame (MF) and 150 large frame (LF) steers fed complete mixed diets containing barley grain and barley silage or GSP and brome hay for 152 day. Trial 2 used 340 LF steers fed one of four diets based on barley grain or GSP as concentrates and barley silage or brome hay as forage sources in a completely randomized design for 140 days. In both trials, all diets were formulated to 12 MJ DE kg/DM and 12% CP (DM basis). Steers fed GSP based diets in trial 1 consumed less feed ($P<0.0\%$) and converted feed to gain more efficiently ($P<0.05$) than barley grain fed steers. In trial 2, steers fed GSP gained faster ($P<0.05$) than those fed barley grain and converted feed to gain more efficiently ($P<0.05$) than steers fed barley grain and brome hay. In both trials, feed costs were reduced with GSP-based diets. Overall, Cattle fed grain screening-based diets exhibited superior gains at lower costs than those fed barley-grain-based diets. These results show that GSP when competitively priced are a good source of energy and protein for use in ruminant diets that will result in similar performance to cattle fed barley-grain based diets when diets are formulated to similar energy and protein levels.

Introduction

The cleaning of grain for export or for use in specialized markets within Canada results in a byproduct commonly known as dockage or screenings. Screenings are defined under the Canada Grain Act and are divided into four classes based on their allowable content of broken grain, fiber, weed seeds and dust. Refuse grain screenings are defined as screenings that do not meet the requirements for Number (No.) 1 or No. 2 feed screenings or uncleaned screenings due to the content of weed seeds, chaff or dust .

Stapleton et al. (1980) concluded that wheat screenings were suitable for use in poultry rations and provided equal growth performance to wheat in balanced broiler rations. Tait et al. (1986) conducted work on the nutritive value and utilization of grain screenings for pigs and sheep. These workers reported No. 1 feed screenings were suitable as a grain for pigs, and that refuse screenings which were highly variable in nutritive value were suitable for ruminant diets.

Determining the chemical composition of byproducts is an essential first step in defining their value as either a protein or an energy source (Johnson et al. 1995). However, further extrapolation or animal trials should be used to complement chemical values (Johnson et al. 1995). These researchers stated that cattle performance is a good indicator of the energy value of byproducts feeds as it integrates the various factors influencing energy values of byproducts including nutrient composition, physical form,

level of inclusion, feed replaced, associative effects and level of intake. Givens et al. (1993) stated that for cereal grain byproducts to be used on farms there should be a regular supply, consistent in composition and in a form that stores well.

The current trend to high throughput grain storage facilities across the prairie provinces indicates that the shipping of unclean grain to export terminals is changing. If grain is cleaned for export on the prairies at a rate of 3.5% dockage, McKinnon et al. (1997) estimated that the amount of screenings available across the prairie provinces totals at least 1.2 million tonnes annually, thus providing a regular supply.

Givens et al. (1993) stated that the relative economic value of any cereal by-product will be judged on its nutritive value compared to traditional feedstuffs. Work conducted by Janzen (1995) has shown that the processing of raw grain screenings into pellets improves the utilization of refuse grain screenings by ruminants and reduces the viability of weed seeds. Janzen (1995) concluded that grain screenings should be considered as an economical feed source for ruminant livestock in Western Canada.

The major feed grain fed to beef cattle in western Canada is barley grain. (Lehman et al. 1997; Ramsey 1994; Mathison et al. 1991). Givens et al. (1993) stated that the assessment of the relative economic value of any cereal grain byproduct should be made on a least cost basis for the whole diet. However, there is no information on the nutritive value and cost of refuse grain screenings relative to regular barley in beef cattle rations or on the growth and performance of feeder cattle fed grain screening-based diets.

The objectives of this study were to develop low cost backgrounding rations that resulted in consistent and predictable gains in feeder cattle and to compare actual performance (ADG, feed intake, feed conversions) of cattle fed processed grain screening pellets (GSP)-based diets with cattle fed barely grain-based backgrounding diets.

Materials and Methods

Animal and Nutritional Management

One hundred and fifty medium frame (MF) Hereford steers (255.2 ± 19.6 kg body weight (BW)) and one hundred and fifty large frame (LF) (259.5 ± 17.2 kg BW) Charolais crossbred steers were purchased from auction markets in late October, 1995 and delivered to the University of Saskatchewan Feedlot, in Saskatoon for trial 1. The induction protocol consisted of processing all steers within 24 h of entry into the feedlot. All steers were vaccinated for clostridial diseases, IBR, and PI_3 (Ultrabac 8 and Bovishield (bovine rhinotracheitis-parainfluenza$_3$)); SmithKline Beecham, West Chester, PA), implanted with Synovex-S, ear tagged and treated with Ivomec (MSD AgVet, Division of Merck Frosst Canada, Inc., Kirkland PQ). All animals with a rectal temperature greater than 40°C were treated with Micotil (Eli Lilly Canada, Scarborough, ON). Following a 10-d acclimation period, the cattle were randomly assigned by

weight and frame size to 12 pens (25 h per pen) and assigned to one of two dietary treatments (2X2 factorial; 3 pen replicates per treatment).

In trial 2, 340 LF (285.0 ± 19.0 kg BW) Charolais crossbred steer calves were purchased from auction markets in late October, 1996 and delivered to the University of Saskatchewan Feedlot, in Saskatoon. The same induction protocol as described in trial 1 was followed. After a 10-d acclimation period, the cattle were randomly assigned by weight group to one of 12 pens (28-29 head/pen) and were fed one of four experimental diets in a completely randomized design. Management practices in both trials followed guidelines set out by the Canadian Council of Animal Care.

Dietary Treatments

In trial 1, 2 diets formulated to 12 MJ DE kg^{-1} DM and 12.0% crude protein were fed. Diet 1 was formulated using barley grain as the primary form of energy and canola meal as a supplemental protein source. Diet 2 was formulated using processed grain screening pellets (GSP) as both a source of energy and protein. GSP were obtained from New-Life Feeds of Saskatoon. These consisted of refuse grain screenings (85%) and lentil screenings (15%) which were blended, ground and steam pelleted (2 mm × 10 mm). The GSP were delivered as required to the University of Saskatchewan Feedlot. Each load was sampled prior to and after pelleting. Forage sources included barley silage, brome/alfalfa hay and wheat straw. These were obtained from the University of Saskatchewan Farm. The brome/alfalfa hay and wheat straw were processed through a Duratech Hay Buster (Model H1000) using a 7.6 cm screen to facilitate feeding. Barley grain was dry rolled prior to feeding.

In trial 2, 4 dietary treatments formulated to 12 MJ DE kg^{-1} DM and 12.5% CP were fed. Diets one and two used barley silage as the forage source with barley grain and GSP as energy sources, respectively. Diets 3 and 4 used brome hay as the principle forage with barley and GSP as energy sources, respectively. All feed was sourced and processed similarly to that in trial 1.

Data Collection and Analytical Procedures

During trial 1 and 2 cattle were weighed unshrunk on two consecutive days at the beginning and the end of the trials and biweekly throughout the duration of each trial before the morning feed had been offered. In trial 1, ultrasound backfat (USFat) measurements were taken monthly and ultrasound longissimus muscle area (USREA) measurements were taken at the start and end of test. During trial 2, USFat measurements were taken monthly, and USREA at the end of test. All ultrasound measurements were taken with an Aloka 500 V realtime ultrasound machine using a 17 cm linear array transducer according to the procedure outlined by Bergen et al. (1996).

The following parameters were monitored throughout both feeding periods and at the completion of each trial: weight gain, fat gain, days on feed, feed consumption and feed efficiency (kg Feed, kg^{-1} gain). Complete mixed diet samples were collected from the feed bunks and individual feed ingredient samples were collected biweekly throughout trial 1. A total of 13 individual loads of GSP were sampled at

the feedlot during trial 1. Throughout trial 2, complete mixed diet samples were collected weekly as the feed was delivered from the feed wagon into the feed bunks and individual feed ingredient samples were collected weekly. A total of 5 individual loads of GSP were sampled at the feedlot during trial 2.

Dry matter content of feed samples was determined in a forced-air oven (60°C for 72 h). Samples were then ground in a Christie-Norris mill (1 mm screen). During trial 1 complete mixed samples were analyzed as collected. Individual feed ingredients were composited into monthly samples for proximate analysis. All samples collected during trial 2 were composited into 4 monthly samples for proximate analysis, except GSP samples. Samples of grain screening pellets from both trials were analyzed for each load delivered to the feedlot. Data on nutrient variation of the GSP samples was given in chapter 2 of this report.

Statistical Analysis

The results from trial 1 data were analyzed as a completely randomized design with a 2 × 2 factorial treatment arrangement using the General Linear Model (GLM) procedure of the Statistical Analysis System, Institute, Inc. (SAS) (1989). The treatment structure included two biological cattle types (medium and large frame), and two dietary treatments. For all animal measurements the pen was used as the experimental unit. Where appropriate, means were separated using the Student-Newman-Keuls procedure (Steel et al. 1997).

Trial 2 data were analyzed as a completely randomized design using the GLM procedure of SAS (1989). Four dietary treatments were compared. Pen was used as the experimental unit. Where appropriate, means were separated using the Student-Newman-Keuls procedure (Steel et al. 1997).

Results and Discussion

Backgrounding Trials

The forage to concentrate ratio, ingredient composition of the concentrates and chemical composition of the complete mixed diets used in trial 1 and trial 2 are presented in Tables 1 and 2. The diets were formulated to 12.0 MJ DE kg^{-1} DM, and 12.0% CP (DM basis) in trial 1. The rations were formulated to meet energy and protein needs for MF and LF steers (255 and 260 Kg, respectively) in trial 1 gaining 0.9 to 1.1 kg d^{-1}, respectively (NAS - NRC 1984 and 1996). In trial 2, the diets were formulated to and 12.0 MJ DE kg^{-1} DM, and 12.5% CP (DM basis) for a target gain of 1.1 kg d^{-1} for 285 kg LF steers. Formulated energy levels (MJ DE kg^{-1} DM) were based on the TDN content of ration ingredients as listed in NAS - NRC (1984, 1996). Grain screening pellet energy levels used in trial 1 were based on previous work conducted by Beames et al. (1986). Trial 2 GSP energy value was based on the values calculated by the CNCPS computer model Version 3 using the CNCPS nutrient analysis of the 13 loads of GSP sampled during 1995 - 1996. The diets in trial 1 consisted primarily of barley silage and barley grain concentrate mix, brome/alfalfa hay and wheat straw or GSP and barley grain concentrate mix fed with brome/alfalfa

hay and straw. The ingredients and nutrient levels used for diet 1 are typical of many commercial backgrounding programs. As such it was used as a control diet to compare the GSP-based diet too. Trial 2 diets consisted of barley grain or GSP as the concentrate and barley silage or brome hay as the roughage source. As in trial 1, the barley grain-based diets were used as controls to compare the performance of cattle fed GSP-based diets.

Trial 1: 1995-96

The performance of the cattle is provided in Table 3 and 4. The medium frame cattle averaged 255.2 ± 19.6 kg and the large frame steers averaged 259.5 ± 17.2 kg at the start of the test with a significant difference noted between frame sizes. After being backgrounded for 152 days the average final weight was 421.9 ± 31.8 kg BW and 420.5 ± 31.0 kg BW for the medium and large frame steers, respectively. There was no influence ($P>0.05$) of frame size or diet on final body weight. There was no influence of frame size or dietary treatment on average daily gain (ADG) (Table 3). During the first 54 days of the trial, all cattle gained in excess of 1.5 kg d^{-1}, with feed conversion ratios of 5.0. This extremely good performance and efficient gains were likely a result of compensatory gain as these cattle were weaned at least 30 days prior to the start of test and had been fed a starter diet up to the start of test. Compensatory gain under such circumstances is well documented (McKinnon et al. 1993; Wright and Russel 1991; Wright et al. 1987; Hironaka and Kozub 1973). During the first 54 days, the cattle had been fed ad libitum. In order to achieve the desired rate of gain for a backgrounding program, the cattle were subsequently restricted in feed intake to achieve a rate of gain of 1.0 to 1.1 kg d^{-1}. The amount of feed subsequently fed in a 2 week period was based on the average daily gain of the pen over the previous 2 weeks.

Overall ADG's were 1.08 ± 0.02 kg per day across both frame sizes and were not influenced ($P>0.05$) by diet. Feed intake was not influenced by frame size. Both the MF and LF cattle fed the GSP-based diet consumed less ($P< 0.05$) feed than the cattle fed the silage-based diet. Consequently, the grain screening fed cattle were more efficient ($P<0.05$) at converting feed to gain (Table 3).

The initial backfat level (Table 4) was 85% greater ($P<0.05$) for the MF cattle (1.69 mm) compared to the LF (0.91mm) cattle. The MF steers maintained a higher ($P<0.05$) level of backfat throughout the trial and backfat was not influenced ($P>0.05$) by diet. The average daily fat gain (ADFG) was greater ($P<0.05$) for the MF than the LF cattle (Table 4)). The final average backfat level (5.01 ± 0.22 mm) for the medium frame steers was greater than the average backfat level of the large frame steers (3.96 ± 0.04 mm) and was not influenced ($P>0.05$) by diet. The difference in fat deposition between the MF cattle and LF cattle agrees with work conducted by Buckley et al. (1990) and Bergen et al. (1997). These researchers established that MF cattle have a more rapid fat deposition at lighter weights and younger ages relative to LF cattle indicating a more advanced physiological maturity.

The initial and final ribeye area of the LF steers was greater ($P<0.05$) than that of the MF steers. The LF steers fed the GSP-based diet had a greater rib eye area at the end of test than the LF steers fed the

barley-based diet. The difference between MF and LF final fat level and rib eye area agrees with the differences in breeds reported by Bergen et al. (1997). These researchers indicated that continental breeds had less fat and larger USREA than the British breeds at the end of test. The LF steers in this trial were Charolais crossbred and the medium frame sized steers were Hereford. Kozub and Hironaka (1991) reported that Hereford steers were fatter than Charolais X Hereford steers and therefore were expected to have a lower energy requirement for maintenance at the same weight. The animals in this trial were not fed to finish but the reduced fat depth and larger longissimus muscle area of LF steers reflect their larger mature size and later maturity compared to the MF steers.

The diets fed in trial 1 were priced using feed and diet processing costs associated with the 1995/96 winter feeding period (Table 5). Feed costs ($ d^{-1}) were lowest ($P<0.05$) for the GSP-based diets (Table 5). Feed costs $ kg^{-1} of gain were lowest ($P<0.05$) for the GSP-based diets ($1.08 ± 0.03 vs $1.17 ± 0.02 $ kg^{-1}). The GSP-based diets cost kg^{-1} of gain was $0.09 lower d^{-1} than the cost of gain for barley-based diets and resulted in a savings of $13.68 for the GSP-based over 152 day feeding period.

Trial 2 1996- 1997

The steers were backgrounded for 142 days during 1996-97 and the performance of the cattle is provided in Table 6 and 7. The start of test weights averaged 285.0 ± 19.0 kg, while end of test final weights averaged 427.1 ± 27.8 kg. Final weights were not influenced by diet ($P>0.05$).

During the first 42-d the steers were fed ad libitum. The steers fed the barley grain-based diets consumed 2.0% - 2.3% of body weight (dry basis). The steers fed the GSP-based diets consumed 2.4% and 2.6% of body weight (DM basis), for the brome hay and silage based GSP diets, respectively. The steers fed GSP-based diets had a higher ($P<0.05$) ADG during the first 42 d (average 1.29 ± 0.02 kg d^{-1}) than the barley grain-based diets (average 1.13 ± 0.02 kg d^{-1}) regardless of forage source. ADG's during this period were all greater than the target ADG of 0.9 - 1.0 kg d^{-1}. Therefore during the last 98 d the steers ADG was regulated to 0.9 to 1.0 kg d^{-1} by limiting dry matter intake to approximately 1.7% to 1.8% of body weight (DM basis). The ADG over the last 98 d averaged 0.93 ±0.15 kg d^{-1} and was not influenced ($P<0.05$) by diet. Over the entire 142 d feeding period, the steers fed the GSP-based diet gained faster ($P<0.05$) than the barley grain-based diets, regardless of forage source.

During the first 42 d the steers fed the GSP/ barley silage-based diet (GSP/BS) and the barley / brome hay-based diet (B/BH) showed no significant difference in intake (7.41 -7.63 DM kg d^{-1}, respectively). The steers fed the GSP/ brome hay-based diet (GSP/BH) had the greatest ($P<0.05$) intake (8.10 kg^{-1}) during the first 42 d. The steers fed the barley / barley silage-based diet (B/BS) had the lowest ($P<0.05$) intake during the first 42 d. During the last 98 d there was no significant difference ($P>0.05$) in DMI of steers fed diet GSP/BS, B/BH or GSP/BH (average 7.57 ± 0.11 kg DM d^{-1}). Steers fed the B/BS continued to have the lowest ($P<0.05$) intake. DMI during the last 98 days averaged 1.7% of body weight

for steers fed B/BS, GSP/BS and GSP/BH diets, and 1.8% for B/BH diet. Overall the steers fed the B/BS diet had the lowest (P<0.05) DMI (7.04 DM kg d^{-1}) and steers fed the GSP-based diets regardless of forage source and B/BH-based diet had the greatest (P<0.05) DMI (average 7.61 DM kg d^{-1} ± 0.13).

During the first 42 d, the steers fed the GSP-based diets were the most efficient (P<0.05) at converting DM to gain, followed by the cattle fed the BG-based diet. Conversions for all cattle during the first 42 d were extremely good. This likely reflects the fact that as in trial 1, these animals during this period were exhibiting compensatory gain (McKinnon et al. 1993; Wright and Russel 1991; Wright et al. 1987; Hironaka and Kozub 1973). There was no significant difference (P>0.05) in feed efficiency across all diets during the last 98 days of the trial. Cattle fed the B/BS-based diet and those fed the GSP-based diets (GSP/BS & GSP/BH diets) were more (P<0.05) efficient at converting feed to gain than the steers fed B/BH-based diet over the entire feeding period. Feed efficiency for the B/BH-based diet was similar (7.76 DM: gain) to the feed efficiency (7.50 DM: gain) reported for control steers fed a diet of barley concentrate, straw and alfalfa/brome hay used in the valuation of wheat-based wet distillers grains for feedlot cattle (Ojowi et al. 1997).

Initial and day 42 ultrasound backfat (USFAT) depths (average 1.09 ±0.11 mm & 1.84 ±0.11 mm, respectively) were not significantly different across diets (Table 7). However, numerically the steers fed the GSP-based diets had higher USFAT on day 42. USFAT during the final 98 days were not significantly different (P>0.05). After 140 days of backgrounding, the steers fed the GSP/BS-based diet had higher (P<0.05) USFAT than the steers fed the B/BS-based diet. The steers fed the GSP-based diets had higher (P<0.05) average daily fat gains (ADFG) than the barley grain-based diets, (average 0.008 ± 0.001 & 0.0045 ± 0.0007 mm d^{-1}, respectively) regardless of roughage source. The steers fed the B/BS-based diet had smaller (P<0.05) USREA (68.11 cm^2) than the GSP-based diets and the B/BH-based diet which were not significantly different (average 71.22 ± 0.68 cm^2).

The diets used in trial 2 were priced using feed and diet processing costs associated with the 1996/97 winter feeding period (Table 8). Feed costs ($ d^{-1}) were lowest for the GSP-based diets and followed the order GSP/BS < GSP/BH < B/BS < B/BH (Table 8). Feed costs kg^{-1} of gain were lowest (P<0.05) for the GSP/BS-based diet, followed by the GSP/BH-based diet, then the B/BS and B/BH-based diets ($0.84<$0.92<$1.08<$1.20, per kg of gain, respectively). The GSP/BS-based diet per kg of gain cost was $0.24 less (P<0.05) than the B/BS-based diet. The GSP/BH-based diet cost per kg of gain was $0.28 lower than the B/BH cost kg^{-1} of gain. Over the course of the feeding trial this resulted in a savings of $25.72 for the GSP/BS-based diet compared to B/BS-based diet and a savings of $29.67 for the GSP/BH-based diet compared to the B/BH-based diet.

In both trial 1 and 2, cattle fed the GSP-based diets exhibited performance that was superior to cattle fed barley grain-based diets, despite the fact that all diets were formulated to similar nutrient densities. The diets were formulated to be isonitrogenous and isocaloric. GSP energy levels used in trial 1 were based on previous work conducted by Beames et al. (1986). Johnson et al. (1995) state that available

energy of byproduct feedstuffs may change as cultivars, inputs, processing methods, and evaluation methods have changed over time. Trial 2 GSP energy values were based on values calculated by the CNCPS computer model Version 3 using results of the CNCPS nutrient analysis of the 13 loads of GSP sampled during 1995 - 1996. Cattle fed GSP-based diets in trial 2 still had better rates of gain than the barley grain fed cattle. If the actual GSP-based diets contained higher energy levels than that predicted from chemical analysis then this underestimation of dietary energy would account for the superior performance of the GSP-fed cattle. According to Johnston et al. (1995) cattle performance is a good indicator of the energy value of byproduct feeds as it incorporates various factors that influence energy values of byproducts including nutrient composition, particle size, level of inclusion, feed replaced, and associative effects. These results indicate that there is a need to do further work to determine the level of intake and the digestible energy content of GSP's.

Conclusions

The conclusions of this study are that:

1. The nutrient content of GSP used in this study showed that the variation in nutrient content is reasonably consistent with starch (% of NSC) and NPN (% of CP) having the greatest variability of the nutrients analyzed.
2. Considering nutrient analysis, and the carbohydrate and protein fraction profile GSP would be good source of energy and protein for ruminants.
3. Grain screening pellet-based diets resulted in consistent superior gains at lower costs than barley grain-based diets for backgrounding steers.
4. There is a need to conduct further work to determine the level of intake and digestible energy content of GSP.

Table 1: Average composition and analysis of Trial 1rations formulated to 12.0 MJ DE kg^{-1} (DM basis) 1995-96.

	Dietary treatment	
	Diet 1	Diet 2
Parameter	Barley-based	GSP-based
Concentrate mix(%)		
Barley [x]	83.6	91.7
Canola meal	9.6	-
Tallow	2.2	2.2
Limestone	1.1	1.7
Salt/mineral [y]/vitamin premix [z]	3.5	4.4
Complete mixed diet (% DM)		
Barley/Concentrate	41.0	25.3
GSP	-	59.5
Barley Silage	35.0	-
Straw	11.0	8.0
Brome Hay	13.0	7.2
Chemical analysis of complete *diet (%)* [v]		
Dry matter	49.9	79.2
Crude protein	11.8	13.1
Acid detergent fiber	23.6	20.7
Neutral detergent fiber	42.7	37.8
Ether extract	3.8	7.0

[z] Vitamin premix: 440,400 IU vitamin A, and 88000 IU vitamin D kg^{-1}.

[y] Trace minerals in mineral premix: 18% calcium, 18% phosphorous, 3150 ppm copper, 5250 ppm manganese, 10500 zinc, 9000 ppm iron, 90 ppm iodine, 33 ppm selenium, 45 ppm cobalt.

[v] Values are averages of samples collected throughout the feeding period.

[x] 22 ppm Monensin (ppm = mg kg^{-1} DM)

Table 2: Average composition and analysis of Trial 2 rations formulated to 12.0 MJ DE kg^{-1} (DM basis) 1996-97.

	Dietary treatment [x]			
Parameter	Diet 1 B/BS	Diet 2 GSP/BS	Diet 3 B/BH	Diet 4 GSP/BH
Concentrate mix(% DM)				
Barley	32.0	34.5	75.2	41.9
Canola meal	62.0	-	21.0	-
GSP	-	50.0	-	45.0
Molasses	0.2	2.5	0.2	2.5
Canola oil	-	0.5	-	0.5
Limestone	3.0	6.5	1.2	3.1
TM Salt /vitamin premix [z]	2.8	6.0	2.4	7.0
Complete mixed diet (% DM)				
Barley/Concentrate	36.0	-	44.0	-
GSP/GSP concentrate	-	52.0	-	70.0
Barley Silage	48.0	36.0	-	-
Straw	16.0	12.0	6.0	11.0
Brome Hay	-	-	50.0	19.0
Chemical analysis of complete *diet (% DM)*[y]				
Dry matter	44.4	50.6	77.4	77.9
Crude protein	13.1	12.5	12.6	12.6
Acid detergent fiber	28.3	27.5	28.0	27.5
Neutral detergent fiber	47.6	44.0	48.7	44.7
Ether extract	2.8	6.0	3.0	6.1

[z] Vitamin premix: 440400 IU vitamin A, and 88000 IU vitamin D kg^{-1}.

Trace mineralized salt: 4000 ppm copper, 10000 ppm manganese, 12000 zinc, 4050 ppm iron, 200 ppm iodine, 120 ppm selenium, 60 ppm cobalt. and 28 ppm monensin

[y] Values are averages of samples collected throughout the feeding period.

[x] Diets: 1 - B/BS = Barley / Barley silage Based

2 - GSP/BS = Grain screening pellets / Barley silage Based

3 - B/BH = Barley / Brome hay Based

4 - GSP/BH = Grain screening pellets / Brome hay / Based

Table 3: Trial 1: Effects of Grain Screening Pellets or Barley on the Performance of Medium and Large Frame Steers.

	Medium Frame		Large Frame		
	Diet 1	Diet 2	Diet 1	Diet 2	
Parameter	Barley-based	GSP-based	Barley-based	GSP-based	SEM [z]
Liveweight (kg)					
Initial	255.8b	254.5b	259.0a	260.0a	1.0
Day 54	340.1a	337.4b	341.0a	344.7a	2.0
Final	423.7	420.1	419.5	421.5	4.2
Average Daily Gain (kg d^{-1})					
Day 0 to 54	1.56	1.54	1.52	1.57	0.037
Overall	1.09	1.09	1.06	1.06	0.033
DM Intake (kg d^{-1})					
Day 0 to 54	7.74	7.79	7.82	7.59	0.21
Overall	7.54a	7.02b	7.35a	6.98b	0.24
Feed Efficiency [y]					
Day 0 to 54	5.01	5.04	5.00	5.04	0.129
Overall	6.92a	6.45b	6.97a	6.56b	0.16

a b c Means in the same row with different letters differ ($p < 0.05$).

[z] SEM = Pooled standard error of the mean.

[y] Kilograms of dry matter per kilogram of gain.

Table 4: Trial 1: Effects of Grain Screening Pellets or Barley on the Performance of Medium and Large Frame Steers

	Medium Frame		Large Frame		
Parameter	Diet 1 Barley-based	Diet 2 GSP-based	Diet 1 Barley-based	Diet 2 GSP-based	SEM [z]
Backfat Depth (mm)					
Initial	1.66a	1.73a	0.75c	1.07b	0.08
Day 0 to 54	4.66a	4.33a	3.10b	3.25b	0.13
Final	5.16a	4.85a	3.94b	3.99b	0.18
Avg. Daily Fat Gain (mm d^{-1})					
Day 0 to 54	0.05a	0.04b	0.04b	0.04b	0.003
Overall	0.02	0.02	0.02	0.02	0.001
Rib Eye Area (cm^2)					
Initial	43.4b	42.3b	47.0a	49.8a	1.0
Final	61.5c	61.7c	65.1b	68.5a	0.5
Feed Costs					
Diet ($ $head^{-1}$ d^{-1})	1.17a	1.07b	1.14a	1.07b	0.04
Gain ($ kg^{-1})	1.15a	1.06b	1.18a	1.10b	0.02

a b c Means in the same row with different letters differ ($p < 0.05$).

[z] SEM = Pooled standard error of the mean.

[x] Kilograms of dry matter per kilogram of gain.

Table 5: Feed ingredient costs of Trial 1 backgrounding diets (1995 - 1996).

Feed Ingredient	Feed Costs Per Tonne (As Fed)
Barley Silage	$ 37
Brome/Alfalfa hay*	$ 94
Wheat Straw*	$ 45
Grain Screening Pellets[z]	$ 120
* Processing charges included ($ tonne^{-1})	$ 21
Grain Concentrate Ingredients	
Barley	$ 142
Canola Meal	$ 525
Tallow	$ 595
1:1 Mineral	$ 528
Limestone	$ 143
Trace Mineralized Salt	$ 242
Rolling /Monensin/Handling charges	$ 21

[z] Delivered price

Table 6:-Trial 2. Effects of grain screening pellets on the performance of large frame steers

Parameter	Dietary treatment				SEM [z]
	Diet 1 B/BS	Diet 2 GSP/BS	Diet 3 B/BH	Diet 4 GSP/BH	
Liveweight (kg)					
Initial	285.0	283.5	285.9	283.9	1.61
Day 0 to Day 42	331.5	337.2	333.8	338.5	2.04
Final (Day 140)	422.3	429.4	424.4	432.3	2.97
Average Daily Gain (kg d^{-1})					
Day 0 to Day 42	1.11b	1.27a	1.14b	1.30a[1]	0.02
Day 42 to Day 140	0.93	0.94	0.92	0.95	0.02
Overall	0.98b	1.04a	0.99b	1.05a	0.01
DM Intake (kg d^{-1})					
Day 0 to Day 42	6.74c	7.41b	7.63b	8.10a	0.12
Day 42 to Day 140	7.17b	7.48a	7.69a	7.55a	0.07
Overall	7.04b	7.46a	7.67a	7.70a	0.08
Feed Efficiency [y]					
Day 0 to Day 42	6.08bc	5.83c	6.70a	6.21b	0.09
Day 42 to Day 140	7.75	7.96	8.34	7.89	0.19
Overall	7.18b	7.17b	7.76a	7.26b	0.11

a b c Means in the same row with different letters differ ($p<.05$).

[z] SEM = Pooled standard error of mean.

[y] Kilograms of dry matter per kilogram of gain.

Table 7: Trial 2. Effects of grain screening pellets on the performance of large frame steers

Parameter	Dietary treatment				SEM [z]
	Diet 1 B/BS	Diet 2 GSP/BS	Diet 3 B/BH	Diet 4 GSP/BH	
Backfat Depth (mm)					
Initial	0.98	1.23	1.10	1.04	0.12
Day 42	1.46	2.12	1.69	2.10	0.17
Final	1.51b	2.40a	1.73ab	2.11ab	0.18
Average Daily Fat Gain (mm d^{-1})					
Day 0 to Day 42	0.013b	0.025b	0.017b	0.03a	0.004
Day 42 to Day 140	0.0003	0.0025	0.0004	.0001	0.0012
Overall	0.004b	0.008a	0.005b	0.008a	.001
Average Rib Eye Area (cm^2)					
Overall Area End of Test	68.1b	70.7a	71.0a	72.0a	0.66
Feed Costs ($)					
$ Per Head/Day	0.96b	0.79d	1.07a	0.89c	0.01
$ Per Kg Gain	1.08b	0.84d	1.20a	0.92c	0.18

a b c Means in the same row with different letters differ ($p<.05$).

[z] SEM = Pooled standard error of mean.

Table 8: -Feed ingredient costs of Trial 2 backgrounding diets (1996 - 1997).

Feed Ingredient	Feed Costs Per Tonne (As Fed)
Barley Silage	$ 30
Brome hay*	$ 85
Wheat Straw*	$ 45
Grain Screening Pellets**	$ 95
* Processing charges	$ 21
** Charges for monensin and freight	$ 9
Grain Concentrate Ingredients	
Barley	$ 101
Canola Meal	$ 269
Molasses	$ 277
1:1 Mineral	$ 766
Limestone	$ 119
Trace Mineralized Salt	$ 242
Rolling/Monensin/Handling charges	$ 24

Chapter 4. Manipulation of Cattle Growth to Target Carcass Quality

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Abstract

Two trials were conducted to determine the effects of breed type, backgrounding program, and backfat endpoint (USBFEP) as determined by ultrasound on the performance and carcass characteristics of feedlot steers. Trial 1 utilized 144 large-framed (LF) Charolais (304.6 ± 16.3 kg) and 144 medium-framed (MF) Hereford- cross steers (294.8 ± 20.9 kg). Trial 2 utilized 88 MF Angus (289.5 ± 15.0 kg), 88 LF Charolais (299.8 ± 17.7 kg), and 88 MF Hereford-cross (291.1 ± 20.9kg) steers. Within breed type, Short (70 d) or Long (126 d) backgrounding programs (Trial 1) and 6 or 12-mm USBFEP (Trial 1 and 2) were assigned. In both trials, carcass size was increased ($P < 0.05$) for the LF Charolais-cross steers and for the longer backgrounding and the fatter USBFEP treatments. Lean meat yield was greater ($P < 0.05$) for Charolais- than Hereford-cross steers (Trial 1) and for the leaner USBFEP (Trial 1 and 2). Marbling was greater ($P < 0.05$) for Angus- (Trial 2) and Charolais-(Trial 1 and 2) than Hereford-cross steers (Trial 1 and 2), and for the fatter endpoint (Trial 1 and 2). It was concluded that breed type, backgrounding program, and USBFEP were effective in altering growth and could be used to target carcass traits of interest for value-based marketing programs.

Introduction

Value-based marketing of cattle involves payment of premiums to feedlot operators capable of supplying animals that meet specific market requirements. For example, many North American packers favor well marbled carcasses with a high retail yield. European markets focus more on lean content of the carcass. Optimal carcass weight varies but is typically less than 409 kg and is often in the range of 272 to 363 kg (Van Donkersgoed et al. 1997).

Frame size is a characteristic of cattle that is related to mature size with the implication that large-framed (LF) cattle will reach a specified level of fatness at heavier weights than small-framed (SF) cattle. Research has related frame size to feedlot performance and carcass grading (Tatum et al., 1986a; Dolezal et al., 1993). Genetic differences amongst cattle breeds have also been related to differences in fat distribution (Berg and Walters, 1983). Commercial slaughter of cattle tends to occur at a similar level of carcass fatness. This approximates equal maturity for breeds differing widely in mature size (Kempster et al., 1982). Selection of animals for slaughter at the same fatness is difficult, but precision can be improved with live animal evaluation techniques (Bergen et al., 1996).

Backgrounding and finishing programs are tools used to adjust the time cattle spend in feedlots. Backgrounding involves feeding for moderate growth allowing for maturation of muscle and bone while restricting fat deposition. Finishing involves consumption of high concentrate rations to maximize growth and fat deposition prior to slaughter (Coleman et al., 1993).

Little data exists on how factors such as breed type, backgrounding program length, and carcass fat endpoint can work together to achieve specific carcass yield and quality grades. The objectives of this study

were to evaluate the effects and interactions of breed type, backgrounding program length, and backfat endpoint on feedlot performance and carcass quality of beef steers.

Materials and Methods

Feedlot Trials. Two feedlot trials were conducted over the winter of 1996-1997 and 1997 – 1998 at the University of Saskatchewan Beef Research Centre in Saskatoon, Saskatchewan. The treatment structure in Trial 1 consisted of a 2 x 2 x 2 factorial arrangement. Factors included breed type (Charolais- and Hereford-cross), length of backgrounding (Short vs Long), and backfat endpoint (USBFEP, 6- vs 12-mm) as determined by ultrasound. One hundred and forty four Charolais- (304.6 ± 16.3 kg) and 144 Hereford-cross (295.1 ± 20.8 kg) steers were used. The cattle were purchased by a commercial order buyer and represented primarily Charolais or Hereford breeding, respectively. These breed types were chosen to represent commercial cattle typical of LF, late maturing and MF, early maturing breeding, respectively. Length of backgrounding was 70 and 126 d for the Short and the Long programs, respectively.. Steers were assigned to 24 pens (12 steers per pen) based on breed type and weight such that within each breed type, each pen was similar in initial body weight. Within a breed type, each pen was randomly assigned to the Short or the Long backgrounding program and the 6 or 12-mm USBFEP.

The treatment structure of Trial 2 was a 3 x 2 factorial arrangement. Main effects were breed type (Charolais-, Angus-, and Hereford-cross steers) and USBFEP (6- vs 12-mm). Eighty-eight MF Angus- (289.7 ± 15.0 kg), 88 LF Charolais- (299.8 ± 17.9 kg) and 88 MF Hereford-cross (291.1 ± 20.9 kg) steers were used. The use of two MF breed types allowed for separation of frame size and breed type effects. The steers were assigned to 24 pens (11 steers per pen) based on breed type and weight, such that within breed type, each pen was similar in initial body weight. Within a breed type, each pen was randomly assigned to the 6 or 12-mm USBFEP. Steers were backgrounded for 70 d, which corresponds to the Short backgrounding used in Trial 1.

Steers in both trials were housed in outdoor pens with protection from prevailing winds via 20% porosity fences and surrounding tree windbreaks. One steer in Trial 1 and three steers in Trial 2 were removed for reasons of illness, injury, or death. In each case, data were removed and pen feed intakes were adjusted accordingly, prior to statistical analysis. Cattle that failed to meet their designated carcass endpoints by a live body weight of 750 kg, or after 308 d on feed, were slaughtered. There were 15 such cattle in Trial 1 and 7 in Trial 2.

Dietary Treatments. Diets were formulated to be typical of western Canadian backgrounding and finishing diets (Table 1). A barley-based concentrate was mixed with an appropriate forage source prior to feeding and fed as a total mixed diet once daily. Backgrounding feed intake was restricted to limit ADG. The LF Charolais-cross steers (Trials 1 and 2) were targeted to gain 1.0 kg/d while the MF Hereford- (Trials 1 and 2) and Angus- (Trial 2) steers were targeted to gain 0.9 kg/d.

At the end of the Short (Trial 1 and 2) or the Long (Trial 1) backgrounding periods, feed intake and diet concentrate content were gradually increased over a four week period to allow *ad libitum* intake of a high

concentrate finishing diet (Table 1). *Ad libitum* feeding of the finishing diet continued until the steers were sent for slaughter.

Steers in both trials were weighed individually with body weights taken before the morning feeding. An average of each steer's weight taken on two consecutive days was recorded for initial and final weight with single weights taken at 14 day intervals throughout the study. All body weights were expressed on a shrunk weight basis (NRC, 1984).

Ultrasound and Carcass Data. Measurements of initial, end of backgrounding, and final USBFEP and longissimus muscle or ribeye (USREA) area were made using real-time ultrasound as described by Bergen et al. (1996). All live animal carcass measurements were made on the left side of the animal between the 12th and 13th ribs using an Aloka 500 V echo camera equipped with a 17.2 cm, 3.5 MHz transducer (Overseas Monitor Corporation, Ltd., Richmond, BC). Final USBFEP and USREA measurements were made in duplicate.

The animals were slaughtered at a federally inspected packing plant. Carcass measurements were obtained through the Canadian Beef Grading Agency from the left side of each carcass following knife ribbing between the 12th and 13th ribs. Measurements taken on the exposed surface of the longissimus muscle included marbling score based on USDA standards (0 = devoid; 1 = traces; 2 = slight; 3 = small or greater) and grade fat which equates to the minimal point of thickness of the subcutaneous fat measured in the fourth quadrant of the longissimus muscle. As well, hot carcass weight was recorded. Commercial seven-bone rib sections (ribs 6 to 12) were collected from the left side of five randomly selected steers from each pen according to guidelines of the Canadian General Standards Board (Anonymous, 1982). Each rib section was weighed and then dissected into bone, lean, and fat components as described by McKinnon et al. (1993). Rib fat was further sub-divided into subcutaneous, body cavity and inter-muscular fat components.

Statistical Analysis. Data from Trials 1 and 2 were analyzed using the GLM procedure of the SAS Institute Inc. (1989). The models used for statistical analysis were:

$Y_{ijkl} = \mu + A_i + B_j + C_k + AB_{ij} + AC_{ik} + BC_{jk} + ABC_{ijk} + e_{ijkl}$ (Trial 1) and

$Y_{ikl} = \mu + A_i + C_k + AC_{ik} + e_{ikl}$ (Trial 2)

Where μ is the general mean, A_i is the main effect of breed type, B_j the main effect of backgrounding program (Trial 1), and C_k the USBFEP main effect. AB_{ij}, AC_{ik} BC_{jk}, and ABC_{ijk} are the two- and three-way interactions, respectively and e_{ijkl} or e_{ikl} are the appropriate experimental error terms. Pen average values constituted experimental units. Means separation was carried out using the analysis of variance results for Trial 1 and the Student-Newman-Keuls procedure for Trial 2.

Results and Discussion

The targeted USBFEP were 6 and 12-mm of backfat. In Trial 1, actual USBFEP was 7.6 and 11.5 mm (Table 2). To be consistent, USBFEP in Trial 2 were targeted to similar levels (8.3 and 12.4 mm; Table 3). In Trial 2, all cattle were backgrounded for 70 days. The longer backgrounding program was not included in the design due to minimal effects on carcass characteristics other than weight, in Trial 1. In both trials, the LF Charolais-cross steers had heavier ($P < 0.05$) initial, end of backgrounding, and final body weights than the MF

Hereford- or Angus-cross steers (Tables 2 and 3). Greater body weight at equal fatness and lower fatness at equal age or body weight has been observed for large- relative to small-framed cattle (Tatum et al., 1986a; Dolezal et al., 1993). In Trial 1, the Long backgrounding resulted in heavier ($P < 0.05$) end of backgrounding and final body weights than the Short backgrounding program. This is in agreement with Coleman et al. (1993) who indicated that backgrounding increased animal size without excessive fattening. Final body weights were heavier ($P < 0.05$) for the 12- than the 6-mm USBFEP in both trials. This is in agreement with data from Buckley et al. (1990) who indicated greater body weights being required for greater fat content.

Initial (Table 2 and 3) and final (Table 4 and 5) backfats were lower ($P < 0.05$) for the LF Charolais- than the MF Hereford- or Angus-cross steers in both trials. End of backgrounding backfat was lower ($P < 0.05$) for the Charolias- than the Hereford- or Angus-cross steers in Trial 2 (Table 3), but not statistically different in Trial 1 (Table 2). Berg and Butterfield (1976) indicated that the portion of fat deposited subcutaneously is greater for early maturing, British than late maturing, Continental breeds. Coleman and Evans (1986) found it necessary to slaughter some of their LF steers at less than desired fatness due to excess size, as was the case in the current study. Backfat thickness ranged from 2.0 to 2.4 mm at the end of the backgrounding period. These results suggest that restricting feed intake to limit daily gains during backgrounding was also effective in limiting backfat accretion. The Long backgrounding (Trial 1) and the 6-mm USBFEP (Trial 1 and 2) resulted in a lower ($P < 0.05$) final backfat than the Short backgrounding or the 12-mm USBFEP (Tables 4 and 5).

Initial, end of backgrounding, and final USREA were larger ($P < 0.05$) for the LF Charolais- than for the MF Hereford-cross steers in both trials (Tables 2, 3, 4 and 5). In Trial 2, Angus-cross steers had smaller ($P < 0.05$) initial, end of backgrounding, and final USREA than Charolais-cross steers (Tables 3 and 5). However, initial and end of backgrounding USREA were larger ($P < 0.05$) in Angus- than Hereford-cross steers. The Long backgrounding in Trial 1 increased ($P < 0.05$) end of backgrounding USREA over the Short backgrounding program (Table 2).

A backgrounding program by USBFEP interaction ($P < 0.05$) was noted for final USREA in Trial 1. Increasing the length of the backgrounding program when steers were fed to the 6-mm USBFEP decreased ($P < 0.05$) the USREA from 84.1 to 82.0 cm^2. However, when fed to the 12-mm USBFEP, increasing the length of backgrounding program increased ($P < 0.05$) the USREA from 93.0 to 95.3 cm^2. The 12-mm USBFEP resulted in larger ($P < 0.05$) final USREA than the 6-mm USBFEP in Trial 2. According to Perkins et al. (1992), live body weight accounts for a significant amount of variation in USREA. The backgrounding program by USBFEP interaction for final USREA (Trial 1) reflects greater recovery by steers subjected to longer backgrounding when fed to a fatter endpoint. Several researchers (Lawrence and Pearce 1964a,b) have indicated that cattle can completely recover from periods of restricted growth when given adequate time. Diet by endpoint interactions for USREA were also noted by Mandell et al. (1997).

Backgrounding and Finishing Performance. Feed intake during backgrounding was restricted to target a predetermined ADG (Tables 2 and 3). In both trials, the LF Charolais-cross steers were permitted a greater ($P < 0.05$) feed intake to target a greater ($P < 0.05$) ADG than the MF Hereford- (Trial 1 and 2) and the MF Angus-cross (Trial 2) steers. The differential rate of gain during backgrounding was chosen to facilitate skeletal and

muscle development of the MF steers prior to being placed on the high energy-finishing ration. This practice is necessary because MF steers initiate fat deposition earlier and at an enhanced rate relative to LF steers (Burg and Butterfield 1976). Minimal treatment effects were noted on feed:gain ratio or in daily accretion of backfat or USREA (Tables 2 and 3) during backgrounding.

Finishing DMI was affected only by backgrounding program in Trial 1, with the Long backgrounding resulting in a greater ($P < 0.05$) finishing DMI than the Short backgrounding program (Table 4). Hicks et al. (1990) reported that DMI is higher for heavier cattle and decreases with extended time on high concentrate diets. Finishing feed to gain ratios were poorer ($P < 0.05$) for the LF Charolais-cross steers (Trials 1 and 2), the Long backgrounding (Trial 1), and the 12-mm USBFEP (Trials 1 and 2) than for the MF Hereford- (Trials 1 and 2) and Angus-cross (Trial 2) steers, the Short backgrounding, and the 6-mm USBFEP, respectively (Tables 4 and 5). Old and Garrett (1987) found Charolais steers to be larger and have lower efficiency of energy utilization for gain than Hereford steers when fed for similar periods of time. Other researchers have reported poorer feed efficiency with increased days on feed as cattle are fed to fatter endpoints (Mandell et al., 1997; Barber et al., 1981). The efficiency of fatter cattle being adversely affected by composition of gain (Robelin and Tulloh, 1992).

The LF Charolais-cross steers had a lower ($P < 0.05$) finishing ADG than the MF Hereford- (Trial 1 and 2) and Angus-cross (Trial 2) steers (Tables 4 and 5). Finishing ADG was greater ($P < 0.05$) for the Long than for the Short backgrounding in Trial 1. The 6-mm USBFEP had a greater ($P < 0.05$) ADG than the 12-mm USBFEP in both trials. Observations of greater ADG for LF cattle are more common (Solis et al., 1989; Tatum et al., 1988), although exceptions do exist (McKinnon et al., 1993). The reduced performance of the LF steers was likely due to a greater allowed backgrounding gain and greater days on feed. Coleman and Evans (1986) found rate of gain during the growing phase to be negatively correlated with rate of gain in the finishing period. Time on feed has been shown to have variable effects on ADG (Hicks et al., 1987; May et al. 1992). However, inherent to sigmoidal growth is the concept that ADG will initially increase and later decrease (Berg and Butterfield, 1976).

A breed type by USBFEP interaction ($P < 0.05$) was noted for finishing days on feed in both trials. Increasing USBFEP from 6- to 12-mm increased finishing days on feed from 93 to 160 d (Trial 1) and from 105 to 178 d (Trial 2) for the LF Charolais-cross steers. However, respective increases in finishing days on feed were smaller for Hereford (78 to 127 d, Trial 1 and 88 to 126 d, Trial 2) and for the Angus-cross (81 to 126 d, Trial 2) steers. Finishing days on feed were reduced ($P < 0.05$) for the Long relative to the Short backgrounding program in Trial 1 (Table 4). Dolezal et al. (1993) found that LF cattle required greater days on feed to achieve a specified backfat thickness than MF cattle. Achievement of a greater degree of lean maturity explains the shorter finishing days on feed for steers subjected to the Long backgrounding program.

A breed type by backgrounding program interaction ($P < .03$) was noted for finishing backfat accretion in Trial 1. Following the Short or the Long backgrounding program, finishing backfat accretion rate averaged 0.06 mm for the LF Charolais-cross steers. However, the MF Hereford-cross steers had a finishing backfat accretion rate of 0.07 and 0.09 mm, following the Short and the Long backgrounding program, respectively.

Finishing backfat accretion rate was greater ($P < 0.05$) for the MF Hereford- and Angus- than the LF Charolais-cross steers in Trial 2 (Table 5). Coleman and Evans (1986) found finishing backfat deposition to be faster for small-framed, older and less restricted steers than for large-framed, younger or more restricted steers. The authors indicated that rate of backfat gain is influenced by proximity to physiological maturity at initiation of finishing.

A backgrounding program by USBFEP interaction ($P < .01$) was noted for the rate of increase in USREA during finishing in Trial 1. Increasing the length of the backgrounding program when steers were fed to the 6-mm USBFEP decreased the rate of increase in USREA from 0.25 to 0.13 cm^2/d. However, when fed to the 12-mm USBFEP, increasing the length of the backgrounding program only decreased the finishing USREA gain from 0.20 to 0.18 cm^2/d. This interaction is related to the two-way interaction for final USREA, discussed previously. The rate of increase for the USREA was greater ($P < 0.05$) for the 6-mm than for the 12-mm USBFEP in Trial 2. This result can be attributed to declining growth rate with greater maturity.

Carcass Characteristics. Effect of treatment on carcass weight in Trials 1 and 2 were consistent with treatment effects on final live body weight mentioned previously. The LF Charolais-cross steers (Trials 1 and 2), the Long backgrounding (Trial 1), and the 12-mm USBFEP (Trials 1 and 2) all resulted in heavier ($P < 0.05$) carcasses (Tables 6 and 7). Charolais-cross steers had greater ($P < 0.05$) marbling scores than Hereford-cross steers in Trials 1 (Table 8) and 2 (Table 9), but were not different from Angus-cross steers in Trial 2. The ability to fatten at earlier ages and weights often results in greater marbling scores for small-framed than large-framed cattle when compared at similar ages or weights (DeRouen et al., 1992). Large-framed steers have been shown to obtain a specified level of marbling at a lower percentage of total separable fat relative to smaller frame steers (Tatum et al., 1986b). Greater ($P < 0.05$) marbling for Angus- than Hereford-cross steers indicates that marbling scores were dependent on breed type and not frame size. Superior marbling has been reported for Angus than Hereford cattle when compared at equal age, live body weight, or fatness (Dubeski et al., 1997a,b). However, Gregory et al. (1994) found Angus and Hereford cattle to have similar marbling scores when compared at equal age. Similar marbling scores have been reported for Angus and Charolais steers when compared at equal fatness or stage of maturity (Barber et al., 1981; Baker and Lunt, 1990). In both trials, the 12-mm USBFEP resulted in greater ($P < 0.05$) marbling scores than the 6-mm USBFEP. Data from Damon et al. (1960) suggest a strong relationship between marbling and overall fatness.

Treatment effects on rib section weight in Trial 1 (Table 6) and 2 (Table 7) are consistent with treatment effects on hot carcass and final live body weight, mentioned previously. The proportion of bone in the rib section was lower ($P < 0.05$) while the proportion of lean was greater ($P < 0.05$) for the LF Charolais- than the MF Hereford-cross steers in Trial 1 (Table 6). However, these differences were not observed in Trial 2 (Table 7). Kempster et al. (1982) reviewed lean:bone ratios for various sire breeds and found progeny from Angus and Charolais bulls to have higher lean:bone ratios than progeny from Hereford bulls. The 6-mm USBFEP resulted in a greater ($P < 0.05$) proportion of bone in the rib section than did the 12-mm USBFEP in both trials, a result consistent with changing proportions of carcass muscle, fat, and bone with time on feed (Berg and Butterfield, 1976).

A backgrounding program by ultrasound backfat endpoint interaction was noted ($P < .04$) for proportion of lean in the rib section in Trial 1. The proportion of lean in the rib section following the Short backgrounding was 55.1 and 48.9% for the 6 and the 12-mm USBFEP, respectively. Following the Long backgrounding, the proportion of lean in the rib section was 54.7 and 50.9% for the 6 and the 12-mm USBFEP, respectively. The smaller change in proportion of lean in the rib section when going from the 6 to the 12-mm USBFEP after the Long backgrounding program reflects the greater ability of steers to recover from longer backgrounding when fed to fatter endpoints, as mentioned previously for final USREA. As expected, the proportion of fat in the rib section was lower ($P < 0.05$) for the 6 than the 12-mm USBFEP in both trials (Table 6 and 7).

The LF Charolais-cross steers had a lower ($P < 0.05$) proportion of subcutaneous and a greater ($P < 0.05$) proportion of inter-muscular fat than the Hereford-cross steers in both trials (Table 6 and 7). Angus-cross steers were not different from Charolais or Hereford-cross steers in Trial 2. The Short backgrounding resulted in a greater proportion ($P < 0.05$) of body cavity and a lower proportion ($P < 0.05$) of inter-muscular fat than the Long backgrounding in Trial 1. The 6-mm USBFEP resulted in a higher ($P < 0.05$) proportion of body cavity fat than the 12-mm USBFEP in both trials. This was accompanied by a decrease ($P < 0.05$) in the proportion of inter-muscular fat in Trial 1. Lower proportions of subcutaneous and higher proportions of internal fat have been associated with increased frame size (Tatum et al., 1986b) and with Continental vs British cattle breeds. With body cavity fat depots maturing earlier than inter-muscular depots (Pálsson, 1955) greater inter-muscular to body cavity fat would result from older or fatter cattle.

Conclusions

These results indicate that management can be manipulated to fit cattle to specific markets. Operators involved with value-based marketing programs that target superior marbling scores could incorporate feeding cattle to a 12 mm USBFEP. Of the three breed-types used in this study, Hereford-cross cattle would be expected to perform poorly in such programs. Programs that target larger, leaner carcasses should incorporate a feeding program based on LF late maturing cattle finished to a 6 mm USBFEP, following a 126 day backgrounding program. Operators involved with value-based programs that target carcasses with high lean content, superior marbling and lighter carcasses need to consider the negative effects of longer backgrounding programs or feeding to fatter end-points particularly for LF cattle. These include larger carcasses, reduced lean content and in the feedlot, poorer gains and feed:gain ratios.

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Table 1 Ingredients make up and chemical analysis of the backgrounding and finishing diets

	Trial 1		Trial 2	
	Backgrounding	Finishing	Backgrounding	Finishing
Total mixed diet, DM basis				
Barley silage	40.8	12.3	32.7	11.5
Cereal straw	12.6	.8	23.5	.2
Concentrate	46.6	86.8	43.8	88.3
Concentrate , DM basis				
Barley grain	69.1	84.4	81.9	87.8
Canola meal	26.1	9.1	10.9	6.1
Tallow	.3	3.6	3.6	3.9
Vitamin premix[a]	1.3	.6	.9	.5
Calcium phosphate mineral mix	.2	-	.1	-
Limestone	1.9	1.7	2.1	1.1
Trace mineral salt[b]	1.1	.6	.5	.6
Chemical composition, DM basis				
Digestible energy, Mcal/kg[c]	3.0	3.5	3.0	3.6
Crude protein, %	13.5	12.5	12.3	12.8
Calcium	.7	.7	.6	.5
Phosphorus	.5	.4	.3	.4

[a]440,400 IU vitamin A and 88,000 IU vitamin D /kg.

[b]4000 ppm copper, 10,000 ppm manganese, 12,000 ppm zinc, 4,050 ppm iron, 200 ppm iodine, 120 ppm selenium, 60 ppm cobalt.

[c]Predicted TDN x 4.4 Mcal/kg (Weiss et al., 1992).

Table 2. Main effects of breed type, backgrounding program, and backfat endpoint on backgrounding performance of steers (Trial 1)

	Breed type		Backgrounding program		Backfat endpoint		
	Charolais	Hereford	70 d	126 d	6 mm	12 mm	SEM
Weight							
Initial, kg	304.6[b]	294.8[c]	299.6	299.7	299.4	299.9	.8
End of backgrounding, kg	401.8[b]	379.5[c]	364.0[c]	417.4[b]	389.7	391.7	2.9
ADG, kg	1.00[b]	.86[c]	.92	.93	.92	.93	.02
Backfat[a]							
Initial, mm	1.4[c]	2.2[b]	1.8	1.8	1.8	1.8	.1
End of backgrounding, mm	2.0	2.4	2.4	2.0	2.2	2.2	.1
ADG, mm	.01[b]	.00[c]	.01[b]	.00[c]	.01	.00	.00
Ribeye area[a]							
Initial, cm^2	55.2[b]	48.0[c]	51.4	51.8	51.7	51.5	.5
End of backgrounding, cm^2	70.8[b]	62.5[c]	61.7[c]	71.5[b]	66.2	67.1	.7
ADG, cm^2	.15	.14	.13	.15	.14	.15	.01
DM intake, kg/d	6.96[b]	6.17[c]	6.46	6.67	6.56	6.57	.11
Feed:gain	7.02	7.22	7.06	7.18	7.14	7.10	.11

[a]Measured with ultrasound between 12th and 13th ribs.

[b,c]Means within main effect in the same row with different superscripts are different ($P < 0.05$).

Table 4. Main effects of breed type, backgrounding program, and backfat endpoint on finishing performance of steers (Trial 1)

	Frame size		Backgrounding program		Ultrasound backfat endpoint		
	Large	Medium	70 d	126 d	6 mm	12 mm	SEM
Final							
Weight, kg	620.1[c]	572.5[d]	584.4[d]	608.2[c]	552.4[d]	640.3[c]	3.7
Backfat, mm	9.1[d]	10.1[c]	9.9[c]	9.3[d]	7.6[d]	11.5[c]	.1
Rib eye area, cm^2[a,b]	94.6[c]	82.6[d]	88.5	88.7	83.0[d]	94.1[c]	.6
Days on feed[b]	127[c]	102[d]	124[c]	105[d]	85[d]	143[c]	3.0
Average daily gain							
Weight, kg	1.78[d]	1.94[c]	1.82[d]	1.90[c]	1.95[c]	1.77[d]	.02
Backfat, mm[a]	.06[d]	.08[c]	.06[d]	.07[c]	.07	.07	< .01
Rib eye area, cm^2[a]	.19	.20	.23[c]	.15[d]	.19	.19	.01
DM intake, kg/d	11.5	11.2	10.7[d]	12.1[c]	11.2	11.5	.11
Feed:gain	6.6[c]	5.9[d]	5.9[d]	6.6[c]	5.9[d]	6.6[c]	.10

[a]Measured with ultrasound between 12th and 13th ribs.

[b]Interaction present ($P < 0.05$).

[c,d]Means within main effect in the same row with different superscripts are different ($P < 0.05$).

Table 5. Main effects of breed type and ultrasound backfat endpoint on finishing performance of steers (Trial 2)

	Breed type			Backfat endpoint		
	Angus	Charolais	Hereford	6 mm	12 mm	SEM
Final						
Weight, kg	545.9[d]	610.8[c]	555.8[d]	533.6[d]	608.1[c]	8.0
Backfat, mm[a]	10.8[c]	9.7[d]	10.5[c]	8.3[d]	12.4[c]	.3
Rib eye area, cm^{2a}	91.5[d]	99.2[c]	88.3[d]	90.3[d]	95.7[c]	1.5
Days on feed[b]	104[d]	142[c]	107[d]	92[d]	144[c]	
Average daily gain						
Weight, kg	1.90[c]	1.76[d]	1.90[c]	1.92[c]	1.78[d]	.05
Backfat, mm[a]	.08[c]	.06[e]	.07[c]	.07	.08	< .01
Rib eye area, cm^{2a}	.25[c]	.21[d]	.23[cd]	.26[c]	.20[d]	.01
DM intake, kg/d	10.66	10.81	10.49	10.58	10.73	.2
Feed:gain	5.69[d]	6.27[c]	5.58[d]	5.54[d]	6.15[c]	.2

[a]Measured with ultrasound between 12th and 13th ribs.

[b]Interaction present ($P < 0.05$).

[c,d]Means within main effect in the same row with different superscripts are different ($P < 0.05$).

Table 6. Main effects of breed type, backgrounding duration, and backfat endpoint on finishing performance of steers (Trial 1)

	Breed type		Backgrounding program		Backfat endpoint		SEM
	Charolais	Hereford	70 d	126 d	6 mm	12 mm	
Carcass weight, kg	368.6[c]	327.9[d]	341.7[d]	354.7[c]	318.6[d]	377.8[c]	2.5
Grade fat, mm[a]	7.3[d]	8.2[c]	7.9	7.6	6.0[c]	9.5[d]	.2
Marbling[ab]	2.0[c]	1.4[d]	1.7	1.7	1.4[d]	2.0[c]	.1
Rib weight, kg	18.36[c]	16.35[d]	16.91[d]	17.80[c]	15.39[d]	19.32[c]	.22
Rib composition, %							
Bone	17.9[d]	18.7[c]	18.5	18.1	19.4[c]	17.2[d]	.2
Lean[a]	53.0[c]	51.8[d]	52.0	52.8	54.9[c]	49.9[d]	.4
Fat	29.1	29.5	29.5	29.1	25.7[d]	32.9[c]	.4
Fat distribution, %							
Subcutaneous	29.7[d]	33.4[c]	31.9	31.1	31.1	32.0	.6
Body cavity	13.2	13.3	13.7[c]	12.8[d]	15.0[c]	11.5[d]	.3
Inter-muscular	57.3[c]	53.3[d]	54.6[d]	56.1[c]	54.2[d]	56.5[c]	.4

[a]Interaction present ($P < 0.05$).

[b]Marbling scores: 0 = devoid, 1 = Traces, 2 = Slight, 3 = Small or greater.

[c,d]Means within main effect in the same row with different superscripts are different ($P < 0.05$).

Table 7. Main effects of breed type and backfat endpoint on rib composition (Trial 2)

	Breed type			Ultrasound backfat endpoint		
	Angus	Charolais	Hereford	6 mm	12 mm	SEM
Hot carcass weight, kg	315.4[c]	356.0[b]	317.4[c]	305.8[c]	353.4[b]	5.1
Grade fat, mm	9.0	8.5	8.5	6.7[c]	10.7[b]	.2
Marbling[a]	2.0[b]	2.1[b]	1.6[c]	1.5[c]	2.3[b]	.1
Rib weight, kg	16.4[c]	18.4[b]	16.5[c]	15.8[c]	18.4[b]	.1
Rib composition, %						
Bone	17.1	17.0	17.7	18.1[b]	16.4[c]	.3
Lean	49.9	50.4	49.3	52.2[b]	47.5[c]	.8
Fat	32.7	32.7	33.0	29.5[c]	36.0[b]	.9
Fat distribution, %						
Subcutaneous	31.9[bc]	30.6[c]	32.9[b]	31.3	32.3	.8
Body cavity	12.3	12.4	12.3	13.4[b]	11.3[c]	.4
Inter-muscular	55.8[bc]	57.0[b]	54.8[c]	55.3	56.4	.7

[a]Marbling scores: 0 = devoid, 1 = Traces, 2 = Slight, 3 = Small or greater.

[b,c]Means within main effect in the same row with different superscripts are different ($P < 0.05$).

Chapter 5. Evaluation of the 1996 NRC Beef Butrition Model

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Abstract

The objective of this trial was to use actual experimental data collected during the backgrounding trials described in chapter 3 to evaluate the National Research Council's (NRC) 1996 Beef Model as a management tool in western Canada. Results indicated that the 1996 NRC beef model overpredicted DMI and underpredicted ADG of limit fed cattle under Saskatchewan environmental conditions. Underprediction of ADG was attributed to the overestimation of maintenance energy needs under the conditions of this study.

Introduction

In 1996, the National Research Council's (NRC) subcommittee on beef nutrition released its 1996 Nutrient Requirements of Beef Cattle publication. The 7th edition was released with a computer program containing two levels of equations based on the CNCP model which were developed to (1) predict nutrient requirements and energy and protein allowable production from the dietary ingredients fed and (2) allow use under widely varying feeding situations (NAS - NRC 1996). The two levels use the same cattle requirement equations which are subdivided into four main sections: maintenance, growth, lactation and pregnancy. Level 1of the model computes ration energy values by summing the energy contribution of each feed to arrive at a total energy content of the ration, using tabular energy values. Tabular energy values used include %TDN, ME(Mcal kg^{-1}) Ne_m (Mcal kg^{-1}) and Ne_g (Mcal kg^{-1}). Level 2 of the model is a mechanistic model designed to obtain additional information about ruminal carbohydrate and protein utilization, and amino acid supply and requirements. Level 2 of the Beef NRC model predicts microbial growth from feed carbohydrate and protein fractions and their digestion and passage rates. These submodels predict variable metabolizable energy (ME), metabolizable protein (MP) and amino acid supplies from feeds based on variations in dry matter intake (DMI), feed composition and feed fiber characteristics utilized under diverse environmental and management conditions. The model contains an extensive feed database with detailed feed composition information that was complied from laboratories across North America and it also contains estimates of the rates of fermentation of various carbohydrate (CHO) and protein (CP) fractions. The feed database also allows a user to enter their own feed analysis results.

The purpose of this study was to evaluate the 1996 NRC Beef Model as a feedlot nutrition management tool for backgrounding calves, utilizing least cost rations containing feed ingredients grown in Western Canada and actual animal performance data obtained from research trials at the University of Saskatchewan.

Materials and Methods

NRC computer Model Prediction of Animal Performance

A description of the reference animal, management and environment is required to evaluate the NRC model. The inputs chosen for the animal description, management and environment are shown in Tables 1 and 2. The animal and management inputs are the overall average per pen for the animals used in the production trials carried out in 1995/96 and 1996/97 and described in Chapter 3. The environmental factors are an average of the measured climatic conditions over the feeding period. The University of Saskatchewan Feedlot has a shelterbelt around its west, north and east sides, plus each pen that was used in the trials had windbreak fences on the west and north side of the pens up to the south facing open faced shelter located on the north fence line of each pen. Measured wind speeds were adjusted to ground speed within the pen. The reported air velocity was reduced by 75% based upon standard recommendations made for windbreak fences and shelterbelts for livestock. (Canada Department of Agriculture, Government of Canada 1978). The individual feeds were sampled throughout each feeding period. All samples were composited into 1 sample per ingredient per trial for analysis except for the grain screening pellets which were analyzed per load. All composited samples and GSP samples were analyzed according to the Cornell Net Carbohydrate and Protein system. The following chemical composition factors were entered into the model for each feed ingredient: crude protein (%DM), neutral detergent fiber (%DM), acid detergent lignin (%NDF), soluble crude protein (%CP), acid detergent fiber insoluble crude protein (%CP), neutral detergent fiber insoluble crude protein (%CP), starch %NSC), fat (%DM), and ash (%DM). The results of the GSP analysis were averaged by feed year and an average per year was entered into the model. The total digestible nutrient values for grain screening pellets (GSP) determined in our digestibility trial (see interim report # 4) were entered into the model. The rates of carbohydrate fermentation and protein degradation, effective NDF, and amino acid composition of undegraded feed protein were obtained from the NRC feed library file for the concentrate and forage ingredients. The appropriate feeds were entered into individual pen files and diet composition was entered. Dry matter intake averages per pen were used to enter feed amounts. Every pen in each year had a separate file.

The computer input values for each pen were changed as required: e.g. body weight (kg), mature weight (kg), age (months), condition score, breeding, use of feed additives. The mature body weight, age, condition score, additives, and on pasture were entered as the same inputs for all pens in that year.

After all the inputs were entered and the model run completed, the results screen for each pen was evaluated by comparing the dry matter intake (DMI) and average daily gain responses predicted by the NRC model with the observed responses from the feedlot trials.

During trial 2 samples of individual feed ingredients and complete mix diets were collected and analyzed for particle size (as-fed basis) according to the standard method described by the American Society of Agricultural Engineers (ASAE) Forage Harvesting and Utilization Committee standard method number S424 (ASAE 1995). Effective NDF (eNDF) was calculated using the following formula:

$$eNDF = \% > 1.18 \text{ mm} * (\%NDF \text{ (DM basis)}/100)$$

where % > 1.18 mm represents the % of total dry matter (DM) retained on a 1.18 sieve multiplied by the NDF content (DM basis) of that fraction. A second computer stimulation was conducted using the eNDF values of the measured forages from trial 2 for the feeds fed in trial 1 and 2 to determine if predictions of DMI and ADG were effected. The eNDF values entered into the model are reported in Table 3.

Previous work at the University of Saskatchewan (Synder et al. 1998 and Synder 1998) indicated that the carbohydrate B2 degradation rate for barley silage (e.g. 10% per hour) in the NRC model was an estimate and that the actual rates of degradation of the B2 fraction for barley silage was 1.09 to 3.54% per hour. Synder et al.(1998) stated that changing the 10% h^{-1} degradation rate to 3.54% h^{-1} , in the CNCPS computer model resulted in a more accurate prediction of fat corrected milk (3.5%). Therefore, a third stimulation was conducted using the CHO B2 degradation rates reported by Synder 1998 for barley silage to determine if predictions by the Beef NRC would be improved. Rates of the CHO B2 degradation for barley (7.6% h^{-1}), GSP 95/96 (2.4% h^{-1}), GSP 96/97 (3.1% h^{-1}) and Brome/alfalfa hay (1.7% h^{-1}) were also adjusted to the values obtained from the in situ digestibility trial as described in Chapter 3.

Statistical Analysis

Selected outputs of the 1996 NRC Beef model were analyzed as a completely randomized block design using the GLM procedure of SAS Institute Inc. (1989) with treatments (Actual, Level 1 and Level 2) as the main effect. The means were separated at a 5% level of significance using the Student-Newman-Keuls test (Steel et al. 1997). Model accuracy was tested by regressing predicted on observed values as described by Rayburn and Fox (1990). Regression of predicted on observed values was conducted on all observed values during the 2 feed years. Two regression models were computed using the GLM procedure of SAS Institute Inc. (1989). The first regression determined the intercept and the coefficient of determination (adjusted r^2) between observed and predicted responses. It also estimated the precision of the predicted responses over the range of observations (standard deviation from regression or root mean square error or standard error of the Y estimate, $S_{y'x}$). The second regression model forced the intercept through the origin to estimate the bias (regression coefficient when the intercept is zero) in predicting the observed responses. The correlation coefficient was determined for the observed and predicted production responses with DMI and ADG as the main effect.

Results and Discussions

Chemical Composition of Feed Ingredients

Composited feed ingredients fed over the two backgrounding feedlot trials (Trial 1-1995-1996 and Trial 2-1996-1997) were analyzed according to the CNCPS and the results are presented in Tables 4 and 5 and were entered into the NRC Beef Model feed data base. The forage to concentrate ratio and ingredient composition of the concentrates have been given in our previous interim report. The completed mixed diets used in trial 1 and 2 were composited by diet, analyzed and the chemical composition is presented in tables 6 and 8. The protein and

carbohydrate fractions of the complete mixed diets are presented in tables 7 and 9.

Evaluation of NRC Beef Model

Figure 1 compares the observed DMI to DMI predicted by Level 1 of the NRC model for Trial 1 over the 1995-97 feeding period. The model accounted for 22% of the variability in DMI. The $S_{y \cdot x}$ of the predicted values about the observed mean was 0.38 kg (Figure 1). Observed DMI was significantly lower ($P<0.05$) than predicted DMI (Table 10). The average bias of level 1 was to over predict DMI by 14.1%. Figure 2 compares the observed DMI to DMI predicted by Level 2 of the NRC model. Level 2 of the model explained 14% of the variation in observed DMI. The average bias of Level 2 was to over predict DMI by 12.3%. There was no significant difference ($P>0.05$) in predicted DMI by level 1 and level 2 (Table 10). Level 2 predicted DMI was greater ($P<0.05$) than observed DMI. The DMI equation for growing calves is based on shrunk live body weight (kgs.) with adjustments for net energy value of diet for maintenance, body fat, feed additive, temperature and mud. The average body weight used to evaluate the DMI prediction for Hereford and Charolais/Hereford crossbred calves in this study was 347.5 ± 9.15 kg. Other researchers (Rayburn and Fox 1996) reported that the CNCPS model over- predicted intake by an average of 7% for Holstein steers weighing over 318 kg.. In this study, in order to limit average daily gain to desired levels, it was necessary to limit feed the cattle. It appears that since the 1996 NRC model relies heavily on body weight to predict intake, it does not account for limit feeding situations and will over-predict intake in such cases.

The model consistently indicated that metabolizable energy (ME) intake was limiting ADG. Figure 3 compares the observed ADG to Level 1 predicted ME allowed ADG. Level 1 of the model accounted for only 3.0% of the variability in ADG. Other researchers (Rayburn and Fox 1989) reported that a small range in ADG values partly explains the low r^2 in their study. All of the observed ADG values in trial 1 and 2 were between 0.96 and 1.20 kg day which is a narrow range of values and contributes to the small r^2 value in this study. The $S_{y \cdot x}$ of predicted ADG about the observed ADG was 0.12 kg. This is similar to the bias reported by Rayburn and Fox (1989). The bias of Level 1 was to under predict ADG by 27.0%. Figure 4 compares observed ADG to level 2 predicted MEADG. Level 2 of the model accounted for 12% of the variability in ADG. The bias of level 2 for MEADG predictions was to underestimate ADG by 15.7%. Observed ADG was greater ($P<0.05$) than level 2 predicted ME allowed ADG which was greater ($P<0.05$) than level 1 predicted ME allowed ADG (Table 10).

Level 1 ration energy values are computed by summing the energy contribution of each feed to arrive at a total energy content of the ration, using tabular values (NRC, 1996). Level 2 uses feed carbohydrate and protein fractions and their digestion and passage rates to predict net energy and metabolizable protein supplied from feed based on the interaction of these variables. Owens et al. (1998) stated that the 1996 NRC Beef Model undervalues the energy content of barley and oat grains. The energy values of the concentrates and brome hay entered into the model were based on digestibility trial values reported previously (Dec/97). However, the model seems to still under value barley-based rations as shown in Table 11. The bias of level 1 MEADG predictions was to under predict the ADG of barley grain-based rations by 32.0%. Level 1 also under predicted the ADG of

the GSP rations by 22.1%. Predictions improved when level 2 was used to predict ADG based on the major concentrate in each diet (Table 11). However the barley grain-based diets were still under predicted by 29.0%. The GSP-based diets ADG was only under predicted by 2.3% when level 2 was used to predict ADG. Predicted diet TDN levels are presented in 12 and 13. Barley-based diets in both trial 1 and trial 2 were predicted to have lower TDN levels than the GSP-based rations. Weiss (1998) suggests that there is a need to incorporate the associative effects of feed on digestion into energy predictions. The 1996 NRC model does not seem to account for the associative effects of barley-based rations.

Entering the measured effective neutral detergent fiber (eNDF) rates into the model resulted in minimum changes to the DMI predicted by level 2 and increased the bias by 3.4% to 15.7%(Table 14). As shown in Table 14 predicted DMI was correlated ($r2 = 0.44$) with observed DMI. Changing the eNDF of the forages (e.g. barley silage and brome hay) resulted in slight numerical decreases in predicted ADG for the barley-based diets and slight numerical improvements for GSP based diets (Table 12 and 13). The under prediction bias of level 2 however, increased to 18.1% for ADG.

Changing the rate of degradation of the carbohydrate (CHO) B2 fraction of barley as discussed by Synder (1998) and using the estimates determined from the degradation data for the GSP, barley and brome/alfalfa hay changed the degradation rates of NDF. The CHO B2 fraction degradation rates for the barley silage was changed from 10% to the levels of 3.54% and 1.09% as evaluated by Synder (1998) for silage grown by the University of Saskatchewan farm. These changes resulted in reduced rates of ADG and lower diet TDN predictions as shown in Tables 12 and 13. Lowering the CHO B2 degradation of barley silage, wheat straw or brome hay decreased the accuracy of predicting ADG in backgrounding calves. When the CHO B2 rate was changed to 3.54 % the bias of level 2 of the model was an underprediction of 31.6%. Changing the CHO B2 rate to 1.09% resulted in an under prediction of ADG of 36.0%. Van Soest et al. (1991) stated that the rate of carbohydrate fermentation will determine the amount of feed energy per unit time that is available for bacteria. Pitt et al. 1997 suggest revised digestion rtes for A, B1 and B2 fractions reduced microbial production of MP and barely affected ME balance. Changing the B2 rates in the NRC model appears to affected ME production the most and only slightly affected MP production. Additional research is required into the description and ruminal digestibility of the A and B1 carbohydrates and VFA yields from Western Canadian feedstuffs. This study also suggests that the NRC model does not account accurately for the performance of barley-based rations when fed to backgrounded steers. Improved estimates of the kinetics will increase the accuracy of predicting animal performance by the 1996 NRC beef model. Further research is required to determine what modifications are required to the prediction equations used in the Beef NRC model to predict energy requirements and supply from western Canadian feedstuffs including associative effects of feedstuffs. The NRC Beef model requires refining to become user friendly and more precise to be used in Western Canadian feedlots.

Conclusions

The conclusions of this study are that:

1. Under the conditions of this study the 1996 NRC beef model underpredicted average daily gain and over-predicted dry matter intake of cattle limit fed backgrounding diets under western Canadian feeding conditions.
2. The NRC beef model predictions of animal performance require modification to improve the accuracy of DMI predictions and ADG performance under Western Canadian conditions.
3. Improved estimates of the kinetics of Western Canadian feedstuffs should increase the accuracy of predicting animal performance by the model.
4. The NRC Beef Model requires modification to become more user friendly to be a useful tool in the feeding industry in Western Canada.

Table 1. Animal description and management practices applied to the reference animal in the NRC model for Trial 1 and 2.

Parameter	NRC Input Screen
Animal Factors	
Animal Type	1 Growing/ finishing
Age	10 Months
Sex	2 Steer
Body Weight[z]	*[z] kg
Condition Score	*[z] 1=emaciated - 9=very fat
Mature Weight	*[z] kg at 28% fat (slight marbling)
Breeding system	*[z] 1 straightbred or 2-way cross
Dams' Breed	*[z] Hereford
Sire's Breed	*[z] Hereford or Charolais
Management Factors	
Additive	4 implant + ionophore
On Pasture?	0 no

[z] Average individual data per pen

Table 2. Environmental conditions entered in the NRC model

	Period	
Environmental factors	Trial 1 1995/96	Trial 2 1996/97
Wind speed	2 km h^{-1}	3 km h^{-1}
Previous Temperature	-10° C	-10° C
Current Temperature	-14° C	-13° C
Night Cooling	yes	yes
Hair Depth	1.3 cm	1.3 cm
Hide	3 thick	3 thick
Hair coat	1 clean & dry	1 clean & dry
Heat Stress	1 none	1 none

Table 3: Effective Neutral Detergent Fiber entered into the NRC Beef Model.

Feed ingredients	Measured effective NDF (%)
Barley silage	53.2
Brome hay- chopped 7.62 cm	44.5
Wheat straw –chopped 7.62 cm	78.8
GSP	30.0

Table 4: Average composition of Trial 1 feed ingredients (DM basis) 1995-96.

Parameter[7]	Barley Grain	Barley Silage	Wheat Straw	Brome/ alfalfa hay	GSP 9596
Ash (% DM)	12.30	9.02	6.04	7.34	6.71
Ether extract (% DM)	1.98	4.13	5	1.46	10.24
Carbohydrate analysis					
NDF (% DM)	33.21	57.73	84.94	59.70	26.46
ADF (% DM)	10.97	32.33	55.97	40.55	15.99
ADL (% NDF)	4.85	5.18	9.30	12.05	9.72
Total Starch (%DM)	44.93	5.20	0.67	0.43	26.17
NSC (% DM)	51.47	16.38	5.78	22.88	36.69
Starch (% of NSC)	87.29	31.76	11.61	1.862	68.35
Protein analysis					
Crude protein (% DM)	12.30	13.73	2.89	11.45	15.04
NPN (% SCP)	83.75	97.83	81.48	84.23	74.51
SCP (% of CP)	24.50	87.40	41.75	35.89	33.91
NDICP (% of CP)	20.55	7.17	34.43	24.67	17.58
ADICP (% of CP)	3.96	5.64	38.77	10.02	7.94

[7] NDF-neutral detergent fiber; ADF-acid detergent fiber; ADL-acid detergent lignin; NSC non-structural carbohydrates; NPN-non protein nitrogen; SCP-soluble crude protein; NDICP-neutral detergent insoluble crude protein; ADICP-acid detergent insoluble crude protein

Table 5: Average composition of feed ingredients Trial 2 (DM basis) 1996-97.

Parameter[3]	Barley Grain	Barley Silage	Wheat Straw	Brome hay	Canola Meal	GSP 9697
Ash (% DM)	3.24	9.9	6.93	6.84	8.01	7.11
Ether extract (% DM)	1.86	3.17	1.13	1.91	3.07	8.88
Carbohydrate analysis						
NDF (% DM)	24.34	56.57	85.86	66.51	42.57	33.69
ADF (% DM)	8.51	33.25	55.84	39.26	254	20.45
ADL (% NDF)	6.04	8.10	8.60	8.58	24.45	12.12
Total Starch (%DM)	55.64	10.14	0.35	0.38	0.83	26.34
NSC (% DM)	61.85	19.97	4.01	19.96	19.19	37.10
Starch (% of NSC)	89.96	50.77	8.62	2.02	4.34	70.80
Protein analysis						
Crude protein (% DM)	10.29	11.47	2.99	9.35	38.49	15.27
NPN (% SCP)	74.14	98.16	84.01	84.45	86.15	36.33
SCP (% of CP)	30.76	75.68	41.46	32.86	20.47	35.61
NDICP (% of CP)	15.37	9.42	31.22	38.33	29.43	13.44
ADICP (% of CP)	3.59	12.53	31.24	14.54	7.11	7.39

[3] NDF-neutral detergent fiber; ADF-acid detergent fiber; ADL-acid detergent lignin; NSC non-structural carbohydrates; NPN-non protein nitrogen; SCP-soluble crude protein; NDICP-neutral detergent insoluble crude protein; ADICP-acid detergent insoluble crude protein

Table 6: Avg. chemical analysis of Trial 1 rations formulated to 12.0 MJ DE kg^{-1} (DM basis) 1995-96.

	Dietary treatment	
Parameter[y]	Barley-Based	GSP-Based
Ash (% DM)	7.14	7.33
Ether extract (% DM)	3.75	6.95
Carbohydrate analysis		
NDF (% DM)	42.72	37.83
ADF (% DM)	23.57	20.74
ADL (% NDF)	7.79	11.31
Total Starch (%DM)	25.88	29.84
NSC (% DM)	36.29	36.79
Starch (% of NSC)	72.03	82.66
Protein analysis		
Crude protein (% DM)	11.75	13.10
NPN (% SCP)	99.95	49.09
SCP (% of CP)	48.78	31.42
NDICP (% of CP)	14.15	15.24
ADICP (% of CP)	5.63	7.24

[y] NDF-neutral detergent fiber; ADF-acid detergent fiber; ADL-acid detergent lignin; NSC non-structural carbohydrates; NPN-non protein nitrogen; SCP-soluble crude protein; NDICP-neutral detergent insoluble crude protein; ADICP-acid detergent insoluble crude protein

Table 7: Protein and carbohydrate fractions of Trial 1 complete mixed diets

Parameter	Dietary Treatment	
	Barley-Based	GSP-Based
Carbohydrate fractions (% DM)		
A (rapidly degradable)	10.2	6.4
B1 (intermediately degradable)	26.1	30.4
B2 (slowly degradable)	33.0	25.6
C (unavailable)	8.0	10.3
True Protein fractions (%CP)		
Total true protein (% of CP)	5.4	10.1
B1 (rapidly degradable)	0.0	16.0
B2 (intermediately degradable)	37.0	53.4
B3 (slowly degradable)	8.6	8.0

Table 8: Avg. chemical analysis of Trial 2 rations formulated to 12.0 MJ DE kg^{-1} (DM basis) 1996-97.

	Dietary treatment[z]			
Parameter[y]	Diet 1 B/BS	Diet 2 GSP/BS	Diet 3 B/BH	Diet 4 GSP/BH
Ash (% DM)	8.68	8.65	7.35	7.58
Ether extract (% DM)	2.46	5.63	2.30	6.15
Carbohydrate analysis				
NDF (% DM)	50.08	45.69	50.33	44.64
ADF (% DM)	28.79	27.69	25.80	26.37
ADL (% NDF)	8.34	10.15	7.91	10.34
Total Starch (%DM)	19.81	21.14	17.59	20.84
NSC (% DM)	27.56	28.65	30.83	31.44
Starch (% of NSC)	71.88	73.80	57.07	66.27
Protein analysis				
Crude protein (% DM)	13.66	12.87	12.92	12.87
NPN (% SCP)	100.00	91.49	91.88	91.61
SCP (% of CP)	42.13	49.46	25.34	31.72
NDICP (% of CP)	17.77	26.57	19.25	20.82
ADICP (% of CP)	7.23	4.30	6.63	7.17

[z] Diets: 1 - B/BS = Barley / Barley silage Based
2 - GSP/BS = Grain screening pellets / Barley silage Based
3 - B/BH = Barley / Brome hay Based
4 - GSP/BH = Grain screening pellets / Brome hay / Based

Table 9: Protein and carbohydrate fractions of Trial 2 complete mixed diets

Parameter	Dietary Treatment			
	Diet 1 B/BS	Diet 2 GSP/BS	Diet 3 B/BH	Diet 4 GSP/BH
Carbohydrate fractions (% DM)				
A (rapidly degradable)	7.8	7.5	13.2	16.6
B1 (intermediately degradable)	19.8	21.2	17.6	20.8
B2 (slowly degradable)	37.7	32.6	38.3	30.9
C (unavailable)	10.0	11.2	9.5	11.0
True Protein fractions (%CP)				
Total true protein (% of CP)	6.9	6.5	9.3	8.2
B1 (rapidly degradable)	0	4.2	2.0	2.6
B2 (intermediately degradable)	40.1	23.7	55.5	47.5
B3 (slowly degradable)	10.6	22.5	12.6	13.6

Table 10: Observed and predicted performance of backgrounded steers using actual chemical analysis of feeds and 1996 NRC Beef model feed degradation rate data.

Parameter	System		
	Observed	NRC Level 1	NRC Level 2
Dry matter intake (kg)	7.34b	8.35a	8.26a
Average daily gain (kg d^{-1})	1.05a	0.77c	0.88b

a b means in the same row with different letters differ ($p<0.05$).

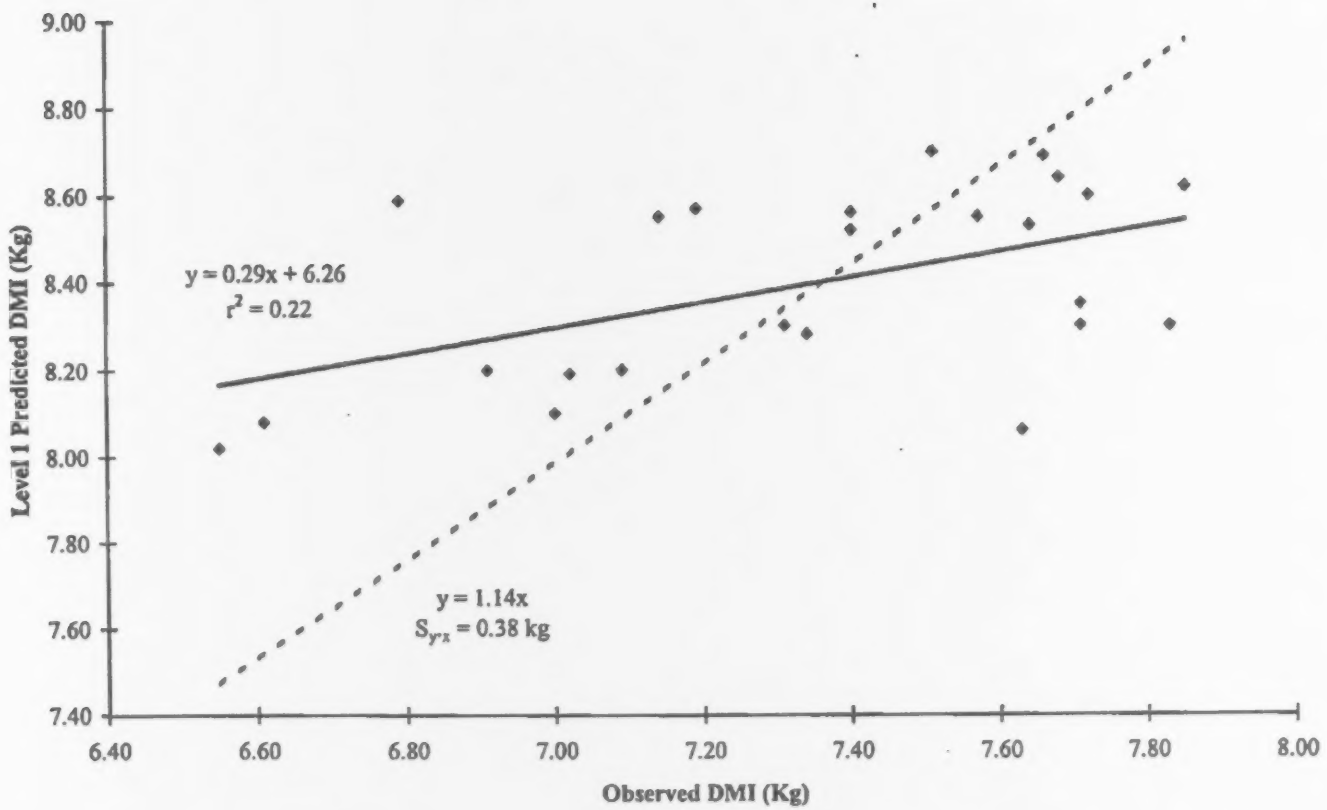

Figure 1: A comparison of NRC Level 1 predicted and observed dry matter intake (DMI) (over prediction bias of 14.10%). Each point represents the mean of 25 or more animals in a pen.

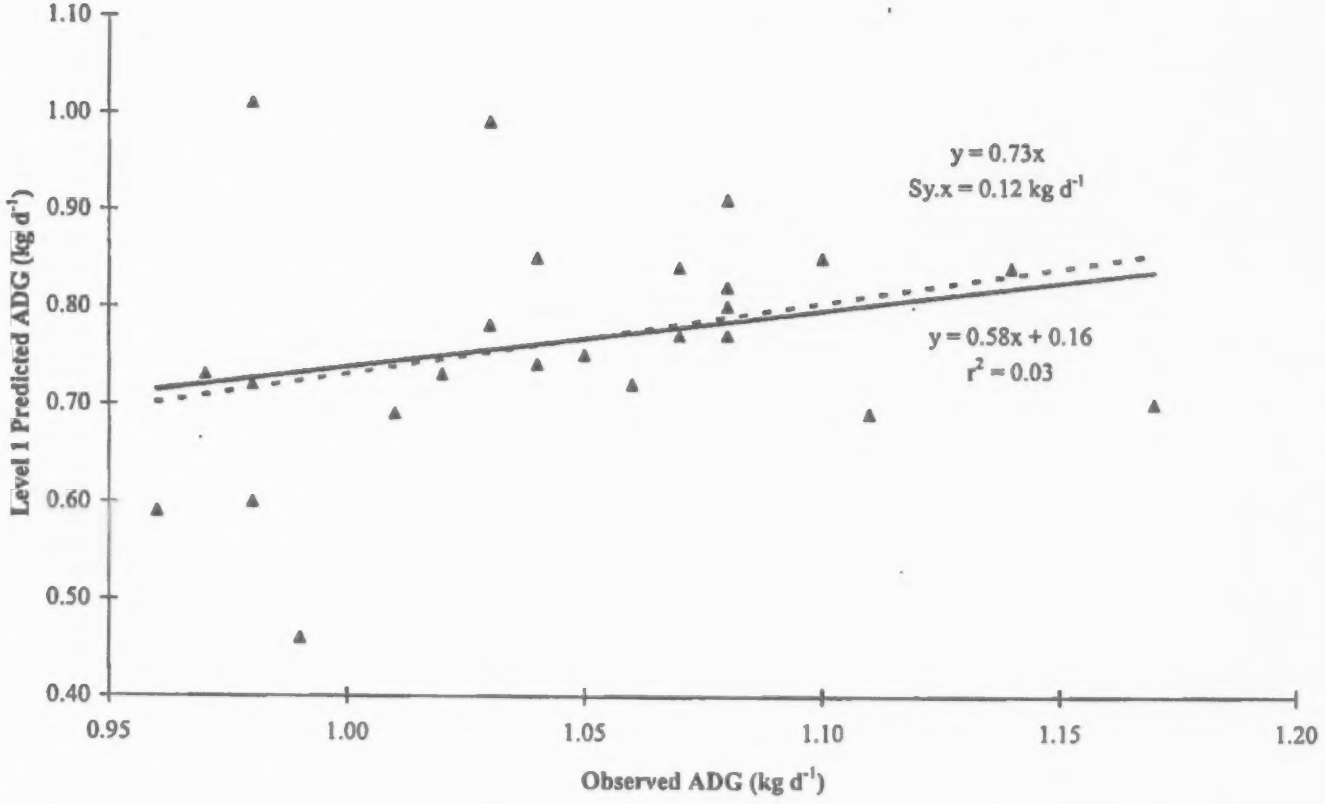

Figure 3 A comparison of NRC Level 1 predicted and actual ADG of Hereford and Charolais crossbred steers (under prediction bias of 27.0%. Each point represents the mean of twenty-five or more animals in a pen.

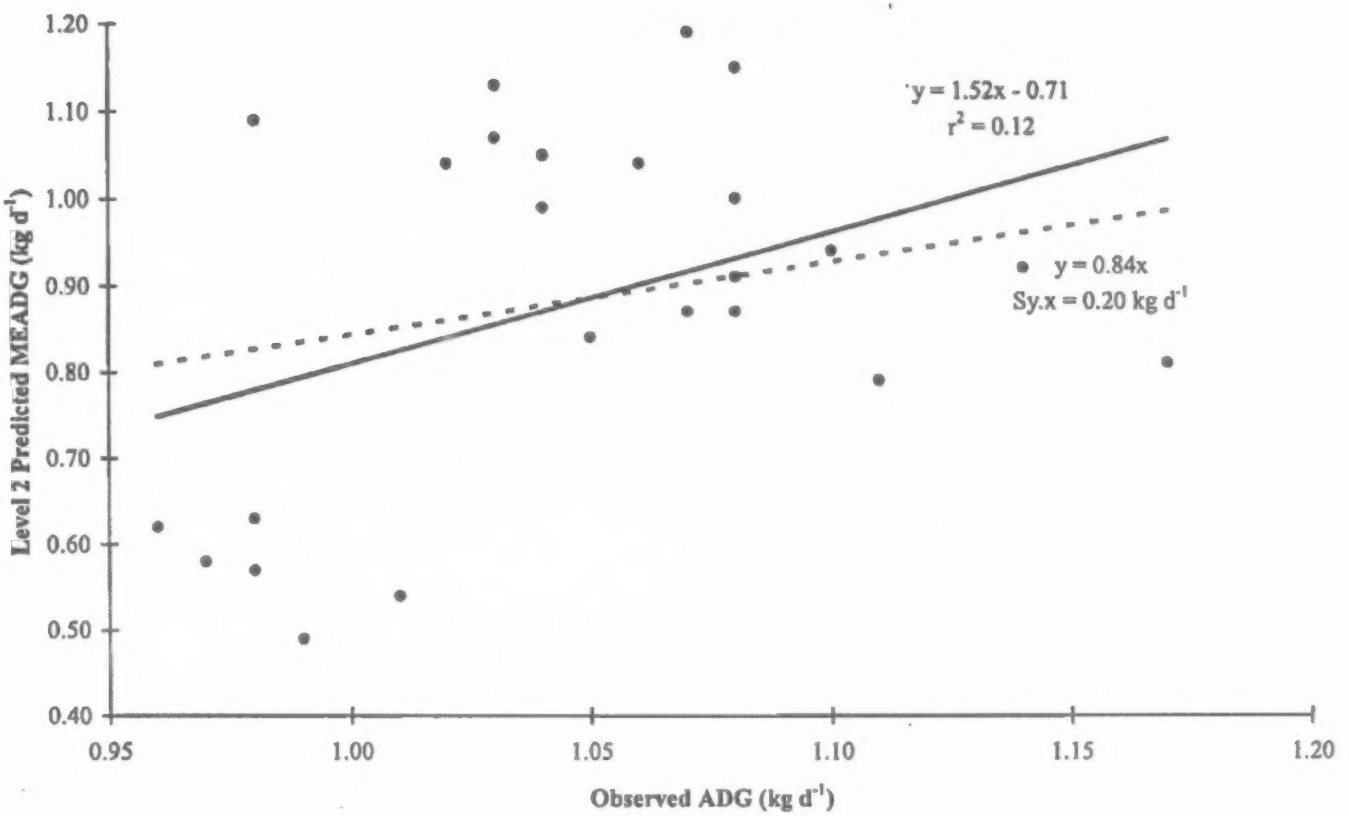

Figure 4: A comparison of NRC Level 2 predicted and actual ADG of Hereford and Charolais crossbred steers (under prediction bias of 15.7%). Each point represents the mean of twenty-five or more animals in a pen.

Table 11: Regression analysis of observed versus 1996 NRC Beef predicted performance of backgrounded steers by major concentrate in diet

Parameter	Barley-based ADG		GSP-based ADG	
	Level 1	Level 2	Level 1	Level 2
Intercept	-0.11	1.18	1.45	1.93
Slope	0.79	1.83	-0.59	-0.85
r^2 (adjusted r^2)	0.14	0.45	0.04	.01
$S_{y \cdot x}$	0.10	0.15	0.12	0.13
N	12	12	12	12
Bias	-32.0	-29.5	-22.1	-2.3

Table 12: Trial 1: Comparison of NRC Beef Model to Actual Performance of Medium and Large Frame Steers fed Grain Screening Pellets or Barley based diets.

Parameter	Medium Frame		Large Frame		SEM [y]
	Barley-based	GSP-based	Barley-based	GSP-based	
Observed					
Initial body weight (kg)	255.8b	254.5b	259.0a	260.0a	1.0
Mid point weight (kg) [z]	339.3	337.3	339.7	340.6	
Final (Day 140) body weight (kg)	423.7	420.1	419.5	425	4.2
DM Intake (kg DM d^{-1})	7.54a	7.02b	7.35a	6.98b	0.24
Average Daily Gain (kg d^{-1}) (ADG)	1.09	1.09	1.06	1.06	0.033
Predicted DM Intake (kg d^{-1})					
NRC Level 1	8.27	8.09	8.27	8.03	
NRC Level 2	8.21	7.94	8.21	7.94	
Predicted MEADG (kg d^{-1}) [x]					
NRC Level 1	0.76	0.86	0.77	0.88	
NRC Level 2	0.88	0.95	0.89	0.98	
NRC Level 2 eNDF rates changed	0.86	0.96	0.87	0.99	
NRC Level 2 CHO B2 - 3.5%	0.82	0.87	0.65	0.86	
NRC Level 2 CHO B2 -1.09%.	0.64	0.82	0.36	0.79	
Predicted Diet Energy (%)					
TDN Level 1	67	73	67	73	
TDN Level 2	69	74	69	74	
TDN Level CHO -3.5%	68	72	65	72	
TDN Level CHO - 1.09%	64	71	59	70	

a b c Means in the same row with different letters differ ($p<.05$).
[z] Average weight used in NRC model evaluation.
[y] S.E.M. = Pooled standard error of the mean.
[x] MEADG = Metabolizable energy allowable ADG.

Table 13: Trial 2. Comparison of NRC Beef Model to Actual Performance of Large Frame Steers fed Grain Screening Pellets or barley based diets

Parameter	Dietary treatment [z]				SEM [y]
	Diet 1 B/BS	Diet 2 GSP/BS	Diet 3 B/BH	Diet 4 GSP/BH	
Observed					
Initial body weight (kg)	285.0	283.5	285.9	283.9	1.61
Mid point weight (kg) [x]	354	357	355	358	
Final (Day 140) body weight (kg)	422.3	429.4	424.4	432.3	2.97
DM Intake (kg DM d^{-1})	7.04b	7.46a	7.67a	7.70a	0.08
Average Daily Gain (kg d^{-1}) (ADG)	0.98b	1.04a	0.99b	1.05a	0.012
Predicted DMI (kg d^{-1})					
NRC Level 1	8.57	8.59	8.61	8.60	
NRC Level 2	8.55	8.31	8.63	8.62	
Predicted MEADG (kg d^{-1}) [x]					
NRC Level 1	0.55	0.73	0.71	0.81	
NRC Level 2	0.58	1.04	0.56	1.16	
NRC Level 2 changed eNDF	0.60	1.02	0.48	1.05	
NRC Level 2 CHO B2 - 3.05%	0.35	0.84	0.34	0.94	
NRC Level 2 CHO B2 - 1.09%	0.01	0.58	0.28	0.90	
Predicted Diet TDN (%)					
TDN Level 1	66	67	65	67	
TDN Level 2	66	74	62	74	
TDN Level 2 CHO rate 3.5%	61	68	58	69	
TDN Level 2 CHO rate 1.09%	54	63	57	65	

a b c Means in the same row with different letters differ ($p<.05$).

[x] Average weight used in NRC model evaluation; MEADG = Metabolizable energy allowable ADG.

[y] S.E.M.=Pooled standard error of mean.

[z] Diets: 1 - B/BS = Barley / Barley silage Based
2 - GSP/BS = Grain screening pellets / Barley silage Based
3 - B/BH = Barley / Brome hay Based
4 - GSP/BH = Grain screening pellets / Brome hay / Based

Table 14: Regression analysis of observed versus 1996 NRC Beef predicted performance of backgrounded steers with modified effective neutral detergent fiber (eNDF) and varying CHO B2 degradation rates.

Parameter	DMI	ADG		
	Modified eNDF	Modified eNDF	CHO B2 rate 3.5%	CHO B2 rate 1.09
Intercept	6.48	-0.73	-1.42	-1.31
Slope	0.22	52	2.04	1.89
r^2 (adjusted r^2)	0.44	0.12	0.17	.02
$S_{y \cdot x}$	0.40	0.20	0.23	0.67
N	24	24	24	24
Bias	15.7	-18.1%	-31.6%	-36.0%

6. Integrated Backgrounding and Finishing Systems that Target Specific Consumer Markets

Agriculture and Agri-Food Canada Melfort and Lacombe Phase

Introduction

The Melfort and Lacombe Research Centres in cooperation with the Department of Animal Science, University of Saskatchewan; the Saskatchewan Horned Cattle Fund; the Saskatchewan Agricultural Development Fund; and the Saskatchewan Beef Development Fund entered into a multi disciplinary research effort to develop systems to lower the cost of backgrounding and finishing beef calves in the Aspen Parkland using forages.

With the loss of the Crow Benefit and lower cash prices for grain production, Saskatchewan beef cattle producers have been seeking information on alternative low cost systems for backgrounding and finishing beef calves in the province. This joint research effort was developed to: a) integrate backgrounding and finishing systems for Saskatchewan cow-calf and feed lot operators; b) determine the economic impact of increased backgrounding of Saskatchewan calves; and c) to liaison with the beef industry to ensure viability and applicability of the research results.

The Melfort/Lacombe phase involved several extended grazing season backgrounding trials using annual ryegrass. Initially two years of research was conducted at the Melfort Research Centre. With the downsizing of the forage/beef program at Melfort, the remaining years of the grazing work were conducted at Lacombe. The research grant from the Saskatchewan Beef Development Fund was mainly used to help finance the backgrounding grazing trials using annual ryegrass. The funds from the Saskatchewan Agriculture Development fund were mainly used to support the finishing feeding trial research and the evaluation of new computer programs called "COWBYTES" for predicting feedlot performance. The funds from the Saskatchewan Horned Cattle Fund were used to evaluate on a small plot basis different types of annuals for extended season grazing.

This all inclusive, multi disciplinary research program, developed systems for growing and finishing calves on various backgrounding and finishing systems. The information and recommendations derived from these studies continues to be disseminated at beef producer conferences and seminars and press releases in Saskatchewan and Western Canada. Producers are adopting these ideas on their own operations in Saskatchewan. This is resulting in a more positive economic benefit to their overall farming operation.

Herbicide Resistance

There have been inquiries on possible herbicide resistance of Italian or annual ryegrass in Canada. We have not observed any herbicide resistance at trials in Melfort. Resistance has been reported in warm temperate climate where the ryegrass plants will overwinter. However the plants appear to not overwinter in western Canada thus reducing the herbicide resistance possibility. The following guidelines are presented to minimize the risk of herbicide resistance in ryegrass:

- Use certified seed.
- Minimize the amount of volunteer ryegrass by:

  a) not allowing forage stands to go to seed.

  b) using Italian ryegrass for forage since most varieties produce few or no heads in the year of seeding. Italian ryegrass requires winter vernalization to produce heads and seed; however, this species is almost never winter hardy in western Canada.

  c) removing as much of the seed from seed fields as possible.
- Promote germination in the fall by packing or harrowing fields - plants that germinate in the fall will be killed by frost.
- Do not cultivate as this buries the seed and will result in a more prolonged emergence period.
- Control spring germinating seedlings with a broad spectrum herbicide such as glyphosate (Roundup, Touchdown or Gramoxone).

Agronomy of Italian Ryegrass

Registered Italian ryegrass seed is costing about $1.45/lb and is available from the major grass seed distributors in Saskatchewan. The seed is slightly larger than other grass seed and as a result can be seeded slightly deeper (at 1/2 to 1" in depth) than other grass seed. Normal grass seeding techniques are important and a firm seed bed is essential. At Melfort and Lacombe seeding was successfully performed at 10-12 lb./acre with a John Deere no till drill, a disc drill and the Brillion seeder. The residual residue from the previous grazing season of Italian ryegrass can cause plugging of the seed drill opener. Extra deep discing was used to incorporate this trash in our studies at Melfort and Lacombe.

Hoe drills did not provide suitable seeding systems as they tended to drag the trash over the fields.

The crop was usually seeded in mid to late May at Melfort and Lacombe after the concerns of potential frost periods. There is concern that the Italian type might vernalize if seeded prior to a spring frost. This would cause the Italian to later set seed.

The fertility and weed control program is very similar to that used in an annuals cereal silage system. Italian ryegrass is very slow to establish and broadleaf weeds should be controlled with 2,4-D or MCPA at the earliest possible time. The ryegrass will not be injured from these herbicides. We ran into weed control problems at Melfort when we waited for the Italian ryegrass to establish before spraying. Ample soil moisture is also required to establish this crop.

The research grazing trials at Melfort and Lacombe emphasized fall grazing. Thus the Italian ryegrass was managed for grazing from early September to mid November and the total year's growth was utilized at that time.

In the initial year of this research program calves were grazed on separate fields of fall rye, Maris Ledger (Italian type) and Aubade (Westerwold type). The material was seeded in the spring and grown throughout the summer to provide the most forage available for fall grazing. We observed, particularly at Melfort and also at Lacombe, that a large proportion of the fall rye leaves died off or showed evidence of stem rust. The Westerwold type, Aubade, set large quantities of seed and became very stemmy. As a result large amounts of the fall rye and the Westerwold type Aubade were wasted and not consumed by the calves. The Maris Ledger (Italian type) was very dense and leafy. It was very slow to establish but responded extremely well with adequate moisture. The leaves remained green and growth continued into the late fall period. Since ryegrass normally grows in warmer climates, the plants did not ciness and shut down for the winter. Quality of the forage remained very high into November with protein in the 14% range and organic matter digestibility of 54%. Ryegrass has a waxy outer leaf coating and this helps preserve the quality of the forage.

Fall Grazing Management

The Italian ryegrass yielded between 4804 and 7440 lb./acre. The crop is extremely leafy and dense and can be trampled quite easily. We recommend the use of strip grazing utilizing a moveable electric fence to ensure the best utilization. In the initial years the calves grazed the entire area but had some difficulty grazing the trampled materials under snow. In subsequent years we utilized the electric fence and only moved the fence when the majority of the crop

had been completed grazed down to the ground. If the fence is moved too quickly, the remaining excess residue will cause plugging problems at seeding time the next year. If the fence is moved too late, and the calves are looking for grazing material, weight gains might be limited. As we moved the fence every two to three days we did not observe a limitation in intake.

During our research program on extending the grazing season for backgrounding calves on annual, forages such as Italian Ryegrass, we have been in contact with research institutions in the winter wheat grazing area of Kansas and Oklahoma. Their grazing season is much longer than ours and the numbers of grazers is vast. The rapid rate of passage of the annuals has been in our studies. The high moisture content and the high digestibility of the forage causes the cattle to be "very loose". Researchers in Kansas and Oklahoma are not concerned about the animals being "loose" and have shown no detrimental effects on the animal's performance. Sometimes they recommend the calves have access to old hay or straw to increase the fibre content of the diet. We provided free choice access to straw or old hay at Melfort and Lacombe as an additional fibre source. The intake of straw or hay was variable over the years and calves still remained loose. The calves later became clean with the provision of bedding straw during the feedlot backgrounding phase of the trial.

Calves successfully grazed during the early snowfalls of November and early December at Melfort and Lacombe. Calves remained on the Italian ryegrass for up to 3 weeks in snow that ranged in depth of 2 to 6" depending on the year. Calves could graze through the snow and trampling of the available forage was not a problem provided the electric fence was used for strip grazing. We would recommend the use of bedding and a portable windbreak shelter if producers decide to prolong grazing under snow.

Results

Melfort Phase

The Melfort herd consisted of Charolais Hereford Angus or Charolais Hereford Semintal type cows bred to composite bulls from Brandon Research Centre. First calf heifers were bred Angus. The herd grazed at the Pathlow Research site during the summer and late fall. Half of the cows were early weaned on August 28, 1995 and 1996. All calves had been pre-vaccinated prior to weaning. The early weaned calves were trucked back to Melfort and allocated

Table 1. 1995.Spring Born Calves at Melfort in lbs.

Treatment	Sex	No.	Early Weaning Wt. Aug 28, 1995	Late Weaning Wt. Oct. 10, 1995	Wt on Feed Jan. 17, 1996	ADG Aug-Jan.
Early Wean Ryegrass	H	23	455.2	496.1	635.8	1.1
Early Wean Ryegrass	S	34	481.6	529.3	675.4	1.2
Late Wean Grazed	H	22	467.1	525.6	667.7	1.3
Late Wean Grazed	S	37	475.4	538.8	686.4	1.4
Late Wean Feedlot	H	23	440.4	493.7	620.4	1.1
Late Wean Feedlot	S	34	487.5	548.7	690.8	1.3

Table 2. 1996 Spring Born Calves at Melfort in lbs.

Treatment	Sex	No.	Early Weaning Wt. Aug 26, 1996	Late Weaning Wt. Oct. 10, 1996	Wt on Feed Dec. 17, 1996	ADG Aug-Dec.
Early Wean Ryegrass	H	27	496.0	523.7	587.1	.81
Early Wean Ryegrass	S	27	520.3	562.7	623.3	.92
Late Wean Grazed	H	26	504.2	552.8	647.7	1.28
Late Wean Grazed	S	28	524.9	582.5	675.3	1.35
Late Wean Feedlot	H	27	487.4	539.0	607.9	1.08
Late Wean Feedlot	S	25	540.7	596.1	663.0	1.09

Table 3. Summary Annual Ryegrass Grazing at Melfort in lbs.

		End of Grazing	ADG/lbs.	Stocking Rate/AC	Gain/AC lbs.
1995	Early Wean	Nov. 1	1.4	4.6	362.3
	Late Wean	Nov. 1	.96	12.0	382.8
1996	Early Wean	Nov. 12	1.4	3.2	322.5
	Late Wean	Nov. 12	2.1	6.6	476.3

Table 4. Steer Finishing and Carcass Summary – Melfort in lbs.

	Treatment	No.	ADG Aug to Slaughter	Shipping Wt.	AAA	AA	A	Yield
1995	Early Wean Ryegrass	30	2.16	1213.0	15	12	3	61.9
	Late Wean Grazed	30	2.25	1234.4	10	18	2	61.4
	Feedlot	33	2.26	1252.2	13	16	4	61.2
			Days on Full Feed					
1996	Early Wean Ryegrass	24	131	1341.7	2	16	6	61.0
	Late Wean Grazed	24	127	1336.4	1	15	8	60.7
	Feedlot	21	122	1349.9	1	11	9	61.4

The 1995 spring born, early weaned calves had lower ADG from the time of early weaning to late weaning than either late weaned treatment group (Table 1). During the backgrounding period from October to January the late weaned grazed calves had a higher ADG than the late weaned feedlot calves, with early weaned calves having intermediate ADG (1.35, 1.18, 1.23 lbs./day, respectively P>0.022). However, the body weights of the calves of backgrounding treatment groups were not significantly different at the time of late weaning, start of finishing, or end of finishing – mostly due to big variation between animals. Male calves were significantly heavier at the time of early weaning and they remained heavier than females until the end of backgrounding, at which time the heifers were separated to be kept as replacement heifers instead of being finished for slaughter. The carcass data of the males slaughtered was not significantly different between the animal treatment groups (Table 4).

The 1996 born early weaned calves had lower ADG between early and late weaning and weighed significantly less than late weaned calves at the time of late weaning (October 1996). During the backgrounding period the late weaned grazed animals had a higher ADG than early weaned or late weaned feedlot cattle and during the backgrounding period, when the heifers were separated to be kept as replacements (December 1996), the early weaned calves weighed significantly less than late weaned feedlot or late weaned grazed animals (605, 635, 662 lbs., respectively P>.02). Male animals were heavier than females at the time of early weaning and remained heavier until the heifers were separated. At the start of the finishing period (April 1997) there was no significant difference between the animals of early weaned, late weaned feedlot or late weaned grazed group, even though there was a trend for early weaned calves being lighter (867, 892, 902, lbs., respectively P>.058). By the end or trial there was no significant difference between the animals of either treatment group (1354, 1360, 1347, lbs., respectively).

Producer Demonstration Trial

A producer demonstration of backgrounding calves on annual ryegrass in the fall was conducted at Lorne Christopherson's farm at Weldon, Saskatchewan in 1995.

Ninety acres of barley was underseeded to Maris Ledger Italian ryegrass and Aubade Westerwold ryegrass (intercrop) in the spring of 1995. Silage was harvested and the regrowth of the ryegrass was later grazed by 120 newly purchased beef calves. The silage crop yielded seven wet tons of material and the Aubade visually out yielded the Maris Ledger. With an intercrop system considerably less annual ryegrass is available for fall grazing as compared to the Maris

Ledger seeded as a mono crop (single crop) and grazed only in the fall.

Two hundred and forty calves were purchased from Spiritwood and Prince Albert stockyards in early October. All calves were vaccinated for respiratory diseases and treated with Micotil (antibiotic) if temperature was elevated. All calves remained in the feedlot for approximately 7 days when the booster shots were given. Calves were weighed and divided into a grazing or background feedlot group. Calves grazed Italian rye fields for 3 weeks in October and then returned to the feedlot, and were backgrounded on the same ration as the feedlot group. The feedlot group received a barley grain, barley silage background ration. All calves were weighed 3 weeks after the conclusion of grazing and in mid-January.

No health problems were encountered in the grazing group. Fifteen cases of major pneumonia were recorded in the feedlot group. Initially, the feedlot calves gained faster than the pasture calves. However, once the grazing calves entered the feedlot they exhibited compensatory gain. As a result, their body weights approached the weights of the feedlot group by the middle of January.

Note: Yields of annual ryegrass regrowth in a silage intercrop system are highly dependent on after silage harvest rainfall and available growing degree days. Producers wishing to grow annual ryegrass or other fall cereals in a barley or oat silage system need to plant the intercrop as early as possible and silage their crops earlier than normal in order to provide adequate time and moisture for fall regrowth of the annual ryegrass.

Lacombe Phase

Another set of extended grazing backgrounding trials were carried out at the Lacombe Research Centre over two years using fall born calves born in 1996 and 1997 and spring born calves born in 1997 and 1998.

Fall Born Calves

Fall born calves (Hereford x Angus and Charolais x Maine-Anjou) in June of 1997 and 1998 were divided into three summer backgrounding treatments with heifer and steers together:

- Group 1: Backgrounded in a feedlot and finished in the feedlot.
- Group 2: Background grazing on perennials until September followed by finishing in a feedlot.

- Group 3: Grazed perennial pasture until September then extended fall grazing on Italian ryegrass followed by finishing in a feedlot.

The cattle were turned out to perennial pastures in early June. Group 1 animals were backgrounded (approximately 1.5 lbs./day gain) on silage and grain and then placed on a finishing ration. Groups 1 and 2 grazed together on perennial forage all summer. In late summer (September 9) the calves from the extended grazing Group 3 are allocated to three replicated fields of Italian ryegrass (Maris Ledger) for late fall grazing until (November 24, 1997 and November 17, 1998). At this time they are allocated to replicated steer or heifer feedlot pens for the finishing phase of the study. Group 2 are placed on finishing diets in late summer (September 9, 1997 – September 10, 1998) following grazing of perennial pasture. Heifers and steers were fed together in replicated groups until the start of the finishing period. Fall calves were not implanted.

Animal weights and backfat levels were monitored monthly throughout the study. All animals were slaughtered over a two-month period at the Lacombe Meat Centre. Carcass yield and quality grade data were obtained at slaughter.

Spring Born Calves

Spring born (Hereford x Angus and Charolais x Maine-Anjou) were early or late weaned in the fall of 1997 or 1998. The calves are divided into three treatments with three replicates.

- Group 1: Early weaned (August 29), background in feedlot and finished in feedlot.
- Group 2: Early weaned (August 29), extended grazing on Italian ryegrass and later backgrounded and finished in feedlot.
- Group 3: Late weaned (October 21), and backgrounded and finished in feedlot.

The fall and spring born calves on the extended grazing treatment had access to Italian ryegrass "Maris Ledger". Grazing was controlled by strip grazing with an electric fence. There were 3 replicated ryegrass paddocks of approximately 3 acres each for both fall and spring calving groups. The electric fence was moved 2-3 times per week after cattle had consumed all available plant material. Cattle grazed the Italian ryegrass down to ground level before having access to new forage. This was done to reduce the amount of residue left in the fields over winter. Free choice salt and mineral were provided in addition to having access to straw in a round bale feeder. Cattle were "loose" due to

the rapid rate of passage of the Italian ryegrass. The steers and heifers grazed together and remained on the pasture until all available forage had been consumed or until the snow became too deep to graze through. The fall and spring born calves were then weighed off of the Italian ryegrass pastures and allocated to steer or heifer feedlot pens for further backgrounding and finishing. Spring born calves were implanted during the finishing phase while fall born calves were not implanted.

Table 5. Performance of Fall and Spring Born Calves at Lacombe

Total gain (lb.)/acre for 1996 fall born calves grazing Italian ryegrass September 9 – November 24, 1997 – 76 days

	Acres	# Animals	Average Initial Wt.	Average Final Wt.	Grazing Days/Acre	Gain/Acre (lb.)
Field 1	2.6	10	588	830	292	500
Field 2	2.7	10	680	923	281	493
Field 6	3.1	10	754	1019	245	465

Total gain (lb.)/acre for 1997 spring born calves grazing Italian ryegrass September 9 – November 24, 1997 – 76 days

	Acres	# Animals	Average Initial Wt.	Average Final Wt.	Grazing Days/Acre	Gain/Acre (lb.)
Field 4	2.9	10	392	572	262	621
Field 3	3.2	10*	457	613	238*	488
Field 5	2.4	10	520	674	316	641

*All calves were in the paddock over the weekend as electric fence was not working properly.

Total gain (lb.)/acre for 1997 fall born calves grazing Italian ryegrass September 9 to November 17, 1997 - 69 days

	Acres	# Animals	Average Initial Wt.	Average Final Wt.	Grazing Days/Acre	Gain/Acre (lb.)
Field 8	3.2	18	615	663	397	275
Field 4	2.7	17	762	808	446	298
Field 9	2.9	17	888	929	412	241

Total gain (lb.)/acre for 1998 spring born calves grazing Italian ryegrass September 9 to December 2, 1998 – 84 days

	Acres	# Animals	Average Initial Wt.	Average Final Wt.	Grazing Days/Acre	Gain/Acre (lb.)
Field 15	1.7	10	406	482	509	462
Field 17	2.2	11	448	531	424	420
Field 2	2.0	10	499	602	430	524

Table 6. Lacombe backgrounding and finishing summary

Season	Background	N	Sex	Weaning Wt. (lbs) 16-Apr-97 LW	Dec.3/97 Wts. 3-Dec-97	Start of Finishing Period Wt (lbs.) 29-Jan-98	Days on feed From Weaning to Start of Finishing	Weaning to Start of Finishing Gain (lbs.)	Weaning to Start of Finishing ADG (lbs.)	Days of Feed from Weaning to Slaughter	Final Slaughter Wt (lbs)	Weaning to Slaughter Gain (lbs.)	Weaning to Slaughter ADG (lbs)
Fall96	Feedlot	12	H	615	997	1115	288	500	1.59	325	1213	599	1 85
Fall96	Feedlot	18	S	619	1084	1232	288	614	2.13	327	1290	671	2.05
Fall96	Pasture/Feedlot	14	H	586	947	1074	288	488	1 69	332	1199	613	1 86
Fall96	Pasture/Feedlot	19	S	627	1030	1183	288	556	1.93	338	1330	702	2 08
Fall96	Ryegrass	10	H	573	908	1027	288	455	1.58	320	1126	553	1 73
Fall96	Ryegrass	20	S	613	1000	1065	288	452	1.57	364	1334	721	1 98
*Fall96	Calves were not implanted												
				29-Aug-97 EW	3-Dec-97	27-Feb-98							
Spring97	Feedlot Early	12	H	451	577	741	180	289	1.61	315	1149	698	2 21
Spring97	Feedlot Early	16	S	455	572	764	180	308	1.71	316	1236	781	2.47
Spring97	Ryegrass	8	H	444	611	789	180	345	1.92	309	1183	739	2.4
Spring97	Ryegrass	17	S	457	636	850	180	419	2.33	314	1302	872	2 78
Spring97	Feedlot Late	17	H	437	618	783	180	346	1.92	313	1192	755	2.42
Spring97	Feedlot Late	34	S	464	647	848	180	396	2 2	305	1293	843	2 76
*Spring97	Calves received implants												
				31-Mar-98 EW	3-Dec-98	17-Nov-98							
Fall97	Feedlot	17	H	471	1004	975	231	505	2 18	323	1225	755	2 35
Fall97	Feedlot	19	S	482	1086	1034	231	548	2 37	336	1331	847	2 54
Fall97	Pasture/Feedlot	21	H	452	926	849	231	399	1.73	362	1264	811	2 24
Fall97	Pasture/Feedlot	21	S	470	950	864	231	398	1 71	374	1328	870	2 33
Fall97	Ryegrass	12	H	423	808	740	231	317	1.37	372	1155	731	1 97
Fall97	Ryegrass	26	S	470	893	817	231	347	1.50	375	1300	830	2 22
*Fall97	Calves were not implanted												
				27-Aug-98 EW	2-Dec-98	23-Feb-99							
Spring98	Feedlot Early	7	H	454	625	790	180	336	1.87	292	1093	639	2 19
Spring98	Feedlot Early	20	S	456	614	836	180	380	2.11	302	1249	793	2.64
Spring98	Ryegrass	8	H	434	637	713	180	278	1 55	312	1120	686	2 20
Spring98	Ryegrass	20	S	461	658	761	180	300	1.67	312	1230	769	2 48
Spring98	Feedlot Late	17	H	442	511	774	180	332	1 84	297	1149	707	2 38
Spring98	Feedlot Late	33	S	469	553	844	180	375	2 08	306	1298	829	2.72
*Spring98	Calves received implants												

Table 7. Lacombe Carcass Data

Season	Background	N	Sex	Hot Trim Carcass Wt (lbs.)	Quality Grade					Yield Grade		
					Prime	AAA	AA	A	B1	B4	Y1	Y2	Y3
Fall96	Feedlot	12	H	693		3	9				9	3	
Fall96	Feedlot	18	S	734		5	12	1			16	2	
Fall96	Pasture/Feedlot	14	H	681		3	10	1			11	3	
Fall96	Pasture/Feedlot	19	S	770		3	12	4			17	2	
Fall96	Ryegrass	10	H	639		4	4	2			9	1	
Fall96	Ryegrass	20	S	754			12	8			20		
Spring97	Feedlot Early	12	H	656			8	4		2	2	4	6
Spring97	Feedlot Early	16	S	695			3	11	2		7	6	3
Spring97	Ryegrass	8	H	675			3	5			3	4	1
Spring97	Ryegrass	17	S	752			4	13			7	7	3
Spring97	Feedlot Late	17	H	687			5	10		2	5	7	5
Spring97	Feedlot Late	34	S	737			7	25	2		15	11	8
Fall97	Feedlot	17	H	705			10	7			9	7	1
Fall97	Feedlot	19	S	774			8	11			11	5	3
Fall97	Pasture/Feedlot	21	H	731	2		14	5			8	12	1
Fall97	Pasture/Feedlot	21	S	775	1		10	10			15	4	2
Fall97	Ryegrass	12	H	659			5	7			7	4	1
Fall97	Ryegrass	26	S	740			11	11	4		18	7	1
Spring98	Feedlot Early	7	H	727			2	5				1	5
Spring98	Feedlot Early	20	S	686			1	13	5	1	7	11	1
Spring98	Ryegrass	6	H	728				6	2		3	1	4
Spring98	Ryegrass	20	S	714			2	15	3		6	11	3
Spring98	Feedlot Late	17	H	656			3	11	2	1	1	7	8
Spring98	Feedlot Late	33	S	684			4	18	7	4	17	11	1

groups on October 21, 1997 (late weaning date) and on February 25, 1998 at the start of the finishing period (817 lbs. vs 781 lbs.). This trend remained at slaughter time. There was very little difference on the number of days from start of finishing to slaughter and for ADG for any of the background treatment groups. At the start of the finishing period in February, early weaned feedlots weighed 747 lbs., early weaned ryegrass 820 lbs. And late weaned feedlot 817 lbs. There was no difference in carcass grade for any of the backgrounding treatments but females had a significantly higher (P>.01) yield grade than steers.

The 1998 spring born calves late weaned calves weighed significantly more (P>.01) than the early weaned calves in February at the start of the finishing period. Steers weighed significantly more than the females. This trend continued at slaughter with late weaning group at 1223 lbs. and early weaning group at 1173 lbs. The early weaned ryegrass groups weighed significantly less (P>.01) at the start of the finishing period 737 lbs. vs 809 lbs. Late weaned feedlot vs 813 lbs. Early weaned feedlot. At slaughter the late weaned feedlot group had significantly greater body weight 1223 lbs. vs early weaned feedlot at 1171 and early weaned ryegrass at 1175 lbs. The average daily gain from start of the finishing period to end of slaughter was similar for all treatment groups but males had significantly higher ADG than females. There were no differences between backgrounding treatments or sex for carcass grades however the females had significantly higher grades than males.

Table 8. Economics of Italian Ryegrass with Yearly Cost of $131.55 at Lacombe

	Grazing Days	Average Grazing Days/Acre	Cost per Day	Average Gain/Acre Lbs.	Cost per Lb.
1996 fall born calves	76	272.6	.48	486	.28
1997 spring born calves	76	289	.46	631	.21
1997 fall born calves	69	418	.31	271	.49
1998 spring born calves	84	454	.29	469	.28

***Cost per Acre Italian Ryegrass at Lacombe**

Establishment Costs	$/Acre
Cultivation	$15.00
Seeding	$ 6.00
Seed 12 lbs. @ 1.45	$17.40
Fertilizer (60-30-40-10) actual	$34.15
Fence repair	$ 1.50
Depreciation on fence	$ 2.00
Land costs	$35.00
Taxes	$ 4.00
Water	$ 2.50
Pasture management (based on $2000/month labor on 160 acres)	$14.00
Total cost per acre	$131.55

*Developed by Campbell Dick and Vern Baron, Lacombe.

The economics of grazing Italian ryegrass can be found on Table 8. Producers can adjust their individual costs using similar inputs used at Lacombe and Melfort. The gain per animal and per acre depends on how long the cattle are left out to graze in the late fall. We grazed into the snow and perhaps producers will not want to do this due to the possible decrease in average daily gain. Our total cost to grow an acre of Italian ryegrass was $131.55. This resulted in a grazing cost per day of $0.29 to $0.48 and a cost of gain from $0.21 to $0.49. Producers and extension agrologists can use the included inputs and evaluate the grazing systems based on local costs and conditions. The big advantage of backgrounding calves on extended season grazing of Italian ryegrass is reduced health problems, less need for stored feed including storage and feeding losses and less labour to feed the cattle and haul manure. All the steers and some of the heifers at Lacombe were finished and slaughtered. During the finishing phase the animals were used to evaluate "Cowbytes" the Alberta Agriculture computer ration formulation program. This will be discussed later in this report. The feed required to finish the cattle is summarized in Table 9 with further details being provided in Table 10. Costs for silage and grain ration fed and yardage are indicated. Producers can change their costs if they wish to use their own prices.

Summary and Recommendations

Beef calves can be successfully backgrounded in the fall by grazing on Italian ryegrass. By extending the grazing season with Italian ryegrass large amounts of very high quality forage can be made available to the calves. Respiratory health problems can be reduced in the fall through extension of the grazing season as compared to housing newly weaned or transported calves in a confined feedlot. Feeding costs and harvesting storage and feed loss costs and labour costs can be reduced in the fall through the extension of the grazing season. Large numbers of calves can graze on small acreages of Italian ryegrass due to its very high quality and productivity. Strip grazing of Italian ryegrass is essential in reducing residue problems at seeding time the following year. Extra tillage will be required to work in the residue.

Depending on snow and late fall winter conditions, producers will need to decide how long they wish to extend the grazing season. It would be advisable to provide some form of portable shelter and bedding if calves remain out in

the early winter snows.

It is highly recommended that the Italian type of ryegrass such as "Maris Ledger" be seeded rather than the Westerwold type "Aubade" as the Westerwold type will produce seed in the year of seeding. Seed shatter will occur and volunteer growth will occur the next year. If the Italian type is unavailable then the Westerwold type should be planted in fields designated for grazing. The crop should be heavily grazed in mid-summer and re-grazed in the late fall after sufficient regrowth has occurred. The initial growth of annual ryegrass is slow in the spring however, with lots of moisture large yields will be available for late fall grazing.

Table 9. Feed Summary Spring 1998 Calves at Lacombe In Kg/Animal

	Animals	Days	Cost/Day $0.20	Silage (kgs)	Silage Cost/kg $0.09	Grain (kgs)	Grain Cost/kg Slaughter $0.17	Total Cost
Early Wean Feedlot - Steers	20							
Total Sept. 10 to Slaughter		289	$57.80	105.78	$95.20	1291.6	$222.16	$375.16
Early Wean Feedlot – Heifers	7							
Total Sept. 10 to Slaughter		281	$56.20	1023.2	$92.09	1110.3	$190.97	$339.26
Late Wean Feedlot - Steers	33							
Total Oct. 27 to Slaughter		247	$49.40	786.8	$70.81	1328.5	$228.50	$348.71
Late Wean Feedlot – Heifers	17							
Total Oct. 27 to Slaughter		238	$47.60	755.4	$67.99	1154.7	$198.61	$314.19
Ryegrass + Feedlot - Steers	20							
Total Dec. 2 to Slaughter		216	$43.20	638.9	$57.50	1209.4	$208.02	$308.72
Ryegrass + Feedlot - Heifers	8							
Total Dec. 2 to Slaughter		215	$43.00	627.2	$56.45	1189.2	$204.54	$303.99

Barley silage priced at $28.75/ton December 1999 Canfax.
Complete grain mix – average tendered price at Lacombe Research Centre.

Feed Summary Fall 1997 Calves Kg/Animal

	Animals	Days	Cost/Day $0.20	Silage (kgs)	Silage Cost/kg $0.09	Grain (kgs)	Grain Cost/kg Slaughter $0.17	Total Cost
Feedlot – Steers	10							
Total June 5-Slaughter		304	$60.80	1165.8	$104.92	1544.1	$265.59	$431.31
Feedlot - Heifers	9							
Total June 5-Slaughter		284	$56.80	1135.2	$102.17	1332.5	$229.19	$388.16
Pasture Feedlot – Steers	21							
Total Sept. 10-Slaughter		209	$41.80	974.6	$87.71	1265.1	$217.60	$347.11
Pasture Feedlot – Heifers	21							
Total Sept. 10-Slaughter		187	$37.40	733.4	$66.01	1197.7	$206.00	$309.41
Ryegrass-Feedlot – Steers	27							
Total Nov. 17-Slaughter		140	$28.00	236.1	$21.25	1164.6	$200.31	$249.56
Ryegrass-Feedlot – Heifers	12							
Total Nov. 17-Slaughter		141	$28.20	219.2	$19.73	1067	$183.52	$231.45

Feed Summary Spring 1997 Calves at Lacombe in Kg./Animals

	Animals	Days	Cost/Day $0.20	Silage (kgs)	Silage Cost/kg $0.09	Grain (kgs)	Grain Cost/kg Slaughter $0.17	Total Cost
Early Wean Feedlot - Steers	17							
Total Sept. 8-Slaughter		307	$61.40	1042.7	$93.84	1368.2	$235.33	$390.57
Early Wean Feedlot - Heifers	10							
Total Sept. 8-Slaughter		307	$61.40	1031.9	$92.87	1352.8	$232.68	$386.95
Late Wean Feedlot - Steers	34							
Total Oct. 25-Slaughter		250	$50.00	884.8	$79.63	1352.2	$232.58	$362.21
Late Wean Feedlot – Heifers	17							
Total Oct. 25-Slaughter		260	$52.00	879.6	$79.16	1381.3	$237.58	$368.75
Ryegrass + Feedlot - Steers	17							
Total Nov. 24-Slaughter		229	$45.80	684.8	$61.63	1432.4	$246.37	$353.80
Ryegrass + Feedlot – Heifers	8							
Total Nov. 24-Slaughter		223	$44.60	668.7	$60.18	1300.7	$223.72	$328.50

Feed Summary Fall 1996 Calves Kg/Animal

	Animals	Days	Cost/Day $0.20	Silage (kgs)	Silage Cost/kg $0.09	Grain (kgs)	Grain Cost/kg Slaughter $0.17	Total Cost
Feedlot - Steers	17							
Total June 16-Slaughter		253	$50.60	1117.8	$100.60	1097.6	$186.59	$337.79
Feedlot - Heifers	12							
Total June 16-Slaughter		265	$53.00	1342.9	$120.86	1107.1	$188.21	$362.07
Pasture Feedlot - Steers	19							
Total Sept. 13-Slaughter		190	$38.00	606	$54.54	1181	$200.77	$293.31
Pasture Feedlot – Heifers	14							
Total Sept. 13-Slaughter		183	$36.60	812	$73.08	1072	$182.24	$291.92
Ryegrass + Feedlot - Steers	20							
Total Nov. 24-Slaughter		144	$28.80	353.7	$31.83	1043	$177.31	$237.94
Ryegrass + Feedlot – Heifers	19							
Total Nov. 24-Slaughter		100	$20.00	323	$29.07	638	$108.46	$157.53

Table 10. Feed Summary Spring 1998 Calves at Lacombe in Kg/Animal

Early Wean Feedlot	Animals	Days	Silage	Grain
Steers	20			
Sept. 10-Dec. 1		83	394.6	117.1
Dec. 2-Feb. 23		84	418.1	223.2
Sept. 10-Feb. 23		167	812.7	340.3
Feb. 24-Slaughter				
May 31		97		
July 19		146	245.1	951.3
Total Sept. 10 to Slaughter			1057.8	1291.6

Early Wean Feedlot	Animals	Days	Silage	Grain
Heifers	7			
Sept. 10-Dec. 1		83	394.6	117.1
Dec. 2-Feb. 23		84	418.1	223.2
Sept. 10-Feb. 23		167	812.7	340.3
Feb 24 to slaughter				
May 31		97		
July 5		131	210.5	770.0
Total Sept. 10 to Slaughter			1023.2	1110.3

Late Weaned Feedlot	Animals	Days	Silage	Grain
Steers	33			
Oct. 27-Dec. 1		36	185.0	72.1
Dec. 2-Feb 23		84	339.2	227.0
Oct. 27-Feb. 23		120	524.2	299.1
Feb. 24 to Slaughter				
May 31		97		
June 7		105	262.6	1029.4
July 19		146		
Aug. 2		161		
Total Oct. 27 to Slaughter			786.8	1328.5

Late Weaned	Animals	Days	Silage	Grain

Heifers	17			
Oct. 27-Dec. 1		36	185.0	72.1
Dec. 2-Feb. 23		84	339.2	227.0
Oct. 27-Feb. 23		120	524.2	299.1
Feb. 24 to Slaughter				
June 7		104		
July 5		131	231.2	855.6
Total Oct. 27 to Slaughter			755.4	1154.7

Ryegrass + Feedlot

	Animals	Days	Silage	Grain
Steers	20			
Dec. 2-Feb. 23		84	390.5	208.1
Feb. 24 to Slaughter				
June 7		104	248.4	1001.3
Aug. 2		160		
Total Dec. 2 to Slaughter			638.9	1209.4

Ryegrass + Feedlot

	Animals	Days	Silage	Grain
Heifers	8			
Dec. 2-Feb. 23		84	390.5	208.1
Feb. 24 to Slaughter				
July 5		131	236.7	981.1
Total Dec. 2 to Slaughter			627.2	1189.2

Feed summary Fall 1997 Calves Kg/Animal

Feedlot

	Days		Animal	Silage	Grain
June 5-Nov. 17	166	S	10	931.8	479.9
		H	9	931.8	479.9
June 5-Dec. 2	181	S		1027.2	561.3
		H		1022.8	554.4
June 5-Slaughter April 5	304	S		1165.8	1544.1
March 15	284	H		1135.2	1332.5

Pasture Feedlot Fall 1997

	Days		Animals	Silage	Grain
Sept 10-Nov. 17	69	S	21	481.6	115.4
		H	21	481.6	115.4
Sept. 10-Dec. 2	84	S		579	204.2
		H		586.6	208.4
Sept. 10-Slaughter					
April 6	209	S		974.6	1265.1
April 14	217				
March 15	187	H		733.4	1197.7
April 7	210				

Ryegrass-Feedlot Fall 1997

	Days		Animals	Silage	Grain
Nov. 17-Dec. 2	16	S	27	79.3	74
		H	12	74.5	68.9
Nov. 17-Slaughter					
April 5,	140	S		236.10	1164.6
April 14	149				
April 6,	141	H		219.2	1067.0
April 7	142				

Feed Summary Fall 1996 Calves at Lacombe in Kg/per Animal

	Animals	Days	Silage	Grain
Feedlot Steers				
June 16-Oct. 15 1997				
Oct. 16-Dec. 2		122	842.1	89.4
Dec. 3-Slaughter	18	48	187.8	310.8
Feb. 10				
March 10	9	69	87.9	697.4
Total June 16 to Slaughter	9	97		
Feb. 10				
March 10	9	239	1117.8	1097.6
	9	267		
Feedlot Heifers				
June 16-Oct. 15				
Oct. 16-Dec 2	12	122	842.1	89.4
Dec. 3-Slaughter		48	256.6	180.4
Feb. 10				
April 2	6	69	244.2	837.3
Total June 16 to Slaughter	6	121		
Feb. 10			1342.9	1107.1
April 2	6	239		
	6	290		
Pasture Feedlot Steers				
Sept. 13-Oct. 15	19			
Oct 16-Dec. 2		33	299.9	
Dec 3-Slaughter		48	198.2	331.2
March 10				
April 2	10	98	108.3	850.1
Total Sept. 13 to Slaughter	9	121		
March 10			606.4	1181.3
April 2		178		
		201		
Pasture Feedlot Heifers				
Sept. 13-Oct. 15	14			
Oct. 16-Dec. 2		33	299.9	
Dec. 3-Slaugther		48	266.1	187
Feb. 24				
April 2		83	246.1	884.7
Total Sept. 13 to Slaughter		121		
Feb. 24			812.1	1071.7
April 2		164		
		121		
Ryegrass Feedlot Steers				
Nov. 24-Dec. 2	20			
Dec. 3-Slaughter		9	62.2	
April 16			291.7	1042.9
April 16		135		
Total Nov. 24-Slaughter		135		
April 16			353.7	1042.9
April 16		144		
		144		
Ryegrass Feedlot Heifers				
Nov. 24-Dec. 2	10			
Dec. 3-Slaugher	9		62.2	
Feb. 24			322.5	
March 10	84		260.3	637.9
Total Sept. 13 to Slaughter	98			
Feb. 24			322.5	637.9
March 10	93			
	107			

Value of Animals at Weaning, December, February and Slaughter

Season	Background	n	Sex	Weaning Wt (lbs)		Weaning value $	Dec.3/97 Wt (lbs)		December value $	Start of Finishing Period Wt (lbs)		February value $	Final Slaughter Wt (lbs)		Slaughter value $
				16-Apr-97 LW	$Apr avg		03-Dec-97	$Dec avg		29-Jan-98	$Feb avg			$Apr avg	
Fall96	Feedlot	12	H	615	$0.96	$590.40	997	$0.88	$877.36	1115	$0.82	$914.30	1213	$0.79	$958.27
Fall96	Feedlot	18	S	619	$1.07	$662.33	1084	$0.93	$1,008.12	1232	$0.93	$1,145.76	1290	$0.83	$1,070.70
Fall96	Pasture/Feedlot	14	H	586	$0.96	$562.56	947	$0.88	$833.36	1074	$0.82	$880.68	1199	$0.79	$947.21
Fall96	Pasture/Feedlot	19	S	627	$1.07	$670.89	1030	$0.93	$957.90	1163	$0.93	$1,100.19	1330	$0.83	$1,103.90
Fall96	Pasture/lt. Ryegrass	10	H	573	$0.96	$550.08	908	$0.88	$799.04	1027	$0.82	$842.14	1128	$0.79	$889.54
Fall96	Pasture/lt. Ryegrass	20	S	613	$1.07	$655.91	1000	$0.93	$930.00	1085	$0.93	$990.45	1334	$0.83	$1,107.22
*Fall96 calves were not implanted.															
				29-Aug-97 EW	$Aug avg		03-Dec-97	$Dec avg		27-Feb-98	$Feb avg			$July avg	
Spring97	Feedlot	12	H	451	$1.02	$460.02	577	$0.97	$559.69	741	$0.88	$652.08	1149	$0.78	$896.22
Spring97	Feedlot	18	S	455	$1.09	$495.95	572	$1.07	$612.04	764	$0.97	$741.08	1238	$0.80	$988.80
Spring97	lt. Ryegrass	8	H	444	$1.02	$452.88	611	$0.95	$580.45	789	$0.88	$694.32	1183	$0.78	$922.74
Spring97	lt. Ryegrass	17	S	457	$1.09	$498.13	638	$1.07	$680.52	850	$0.97	$824.50	1302	$0.80	$1,041.60
Spring97	Feedlot	17	H	437	$1.02	$445.74	616	$0.95	$587.10	783	$0.88	$689.04	1182	$0.78	$929.76
Spring97	Feedlot	34	S	464	$1.09	$505.76	647	$1.07	$692.29	846	$0.97	$820.62	1293	$0.80	$1,034.40
*Spring97 calves received implants.															
				31-Mar-98 EW	$Apr avg		03-Dec-98	$Dec avg		17-Nov-98				$Apr avg	
fall97calf	Feedlot	17	H	471	$0.93	438	1004	$0.88	$883.52	975	$0.88	$858.28	1225	$0.79	$968.12
fall97calf	Feedlot	19	S	482	$1.13	$544.60	1088	$0.93	$1,009.98	1034	$0.93	$961.52	1331	$0.83	$1,104.56
fall97calf	Pasture/Feedlot	21	H	452	$0.93	421	926	$0.88	$814.88	849	$0.88	$746.81	1284	$0.79	$998.22
fall97calf	Pasture/Feedlot	21	S	470	$1.13	$531.34	950	$0.93	$883.50	864	$0.93	$803.34	1328	$0.83	$1,102.48
fall97calf	Pasture/lt. Ryegrass	12	H	423	$0.93	394	806	$0.88	$709.28	740	$0.88	$651.35	1185	$0.79	$912.32
fall97calf	Pasture/lt. Ryegrass	28	S	470	$1.13	$531.58	893	$0.93	$830.49	817	$0.93	$760.13	1300	$0.83	$1,079.35
*Fall97 calves were not implanted.															
				8/27/98 EW	$Aug avg		02-Dec-98	$Dec avg		2/23/99	$Feb avg			$July avg	
spr98calf	Feedlot	7	H	454	$1.02	$463.52	625	$0.95	$593.75	790	$0.88	$695.45	1093	$0.78	$852.87
spr98calf	Feedlot	20	S	456	$1.09	$497.31	614	$1.01	$620.14	838	$0.93	$777.67	1249	$0.80	$999.16
spr98calf	lt. Ryegrass	8	H	434	$1.02	$442.94	637	$0.95	$605.15	713	$0.88	$627.11	1120	$0.78	$873.41
spr98calf	lt. Ryegrass	20	S	461	$1.09	$502.82	656	$1.01	$664.58	781	$1.04	$791.75	1230	$0.80	$983.88
spr98calf	Feedlot	17	H	442	$1.02	$450.90	511	$0.97	$495.67	774	$0.88	$681.17	1149	$0.78	$896.50
spr98calf	Feedlot	33	S	469	$1.09	$511.24	553	$1.01	$558.53	844	$0.93	$784.53	1298	$0.80	$1,038.30
*Spring98 calves received implants.															

5 year average Saskatchewan prices by month were used.